Machine Learning Lab Assignment 3

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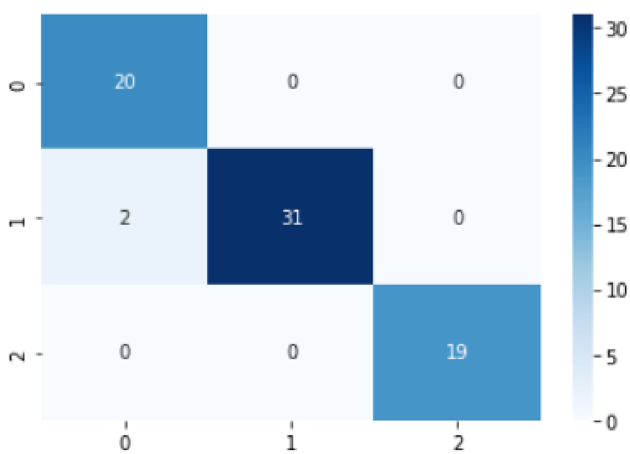
Semester - 7
Year - 4
Department - Information Technology

1) Wine Dataset

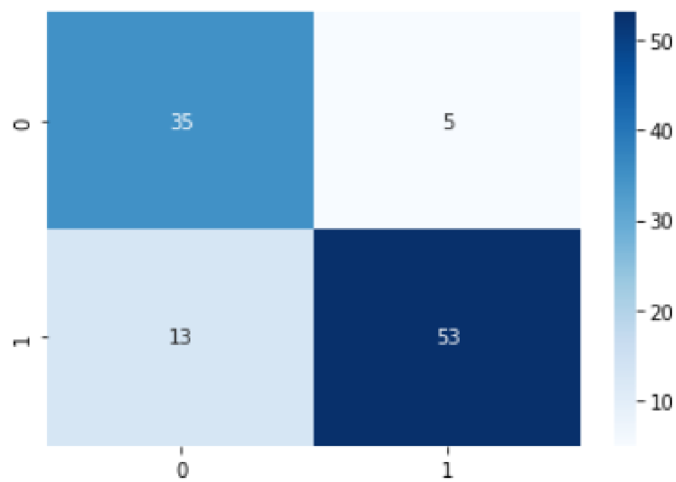
1.1) GaussianHMM Without Tuning

```
Confusion Matrix:
[[20  0  0]
 [ 2 31  0]
 [ 0  0 19]]
--------------------------------------------------
--------------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           1       0.91      1.00      0.95        20
           2       1.00      0.94      0.97        33
           3       1.00      1.00      1.00        19

    accuracy                           0.97        72
   macro avg       0.97      0.98      0.97        72
weighted avg       0.97      0.97      0.97        72

--------------------------------------------------
--------------------------------------------------
Accuracy:
0.9722222222222222
```



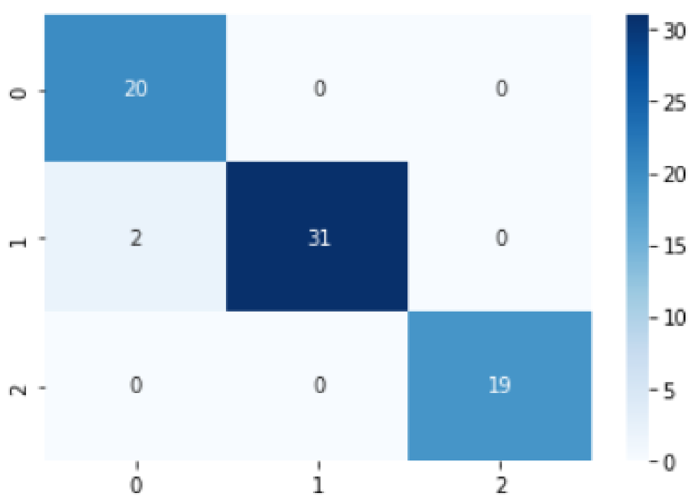
1.2) GaussianHMM With Tuning

```
Confusion Matrix:
[[35  5]
 [13 53]]
--------------------------------------------------
--------------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           b       0.73      0.88      0.80        40
           g       0.91      0.80      0.85        66

    accuracy                           0.83       106
   macro avg       0.82      0.84      0.83       106
weighted avg       0.84      0.83      0.83       106

--------------------------------------------------
--------------------------------------------------
Accuracy:
0.8301886792452831
```



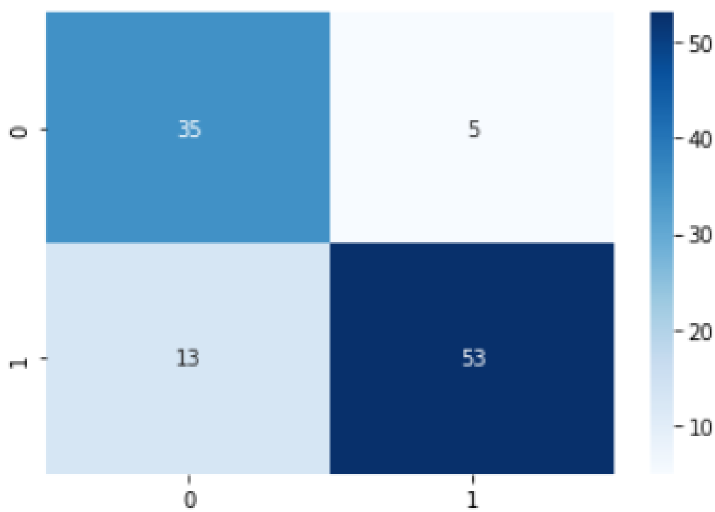
1.3) GMMHMM Without Tuning

```
Confusion Matrix:
[[20  0  0]
 [ 2 31  0]
 [ 0  0 19]]
-------------------------------------------------
-------------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           1       0.91      1.00      0.95        20
           2       1.00      0.94      0.97        33
           3       1.00      1.00      1.00        19

    accuracy                           0.97        72
   macro avg       0.97      0.98      0.97        72
weighted avg       0.97      0.97      0.97        72

-------------------------------------------------
-------------------------------------------------
Accuracy:
0.9722222222222222
```



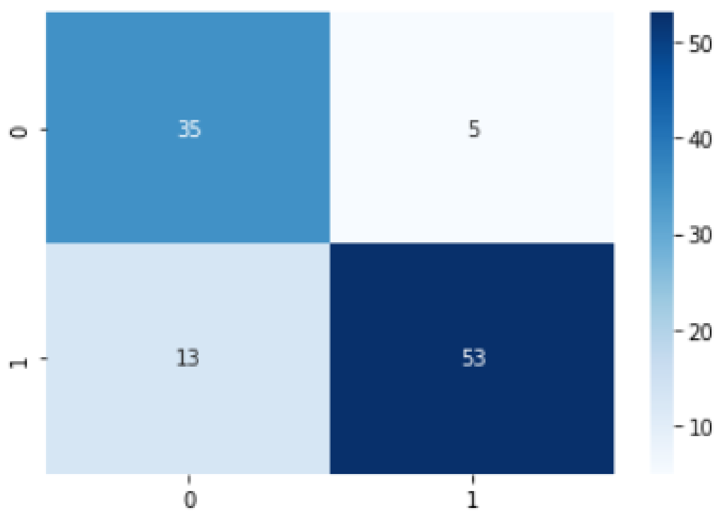
1.4) GMMHMM With Tuning

```
Confusion Matrix:
[[35  5]
 [13 53]]
--------------------------------------------------
--------------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           b       0.73      0.88      0.80        40
           g       0.91      0.80      0.85        66

    accuracy                           0.83       106
   macro avg       0.82      0.84      0.83       106
weighted avg       0.84      0.83      0.83       106

--------------------------------------------------
--------------------------------------------------
Accuracy:
0.8301886792452831
```



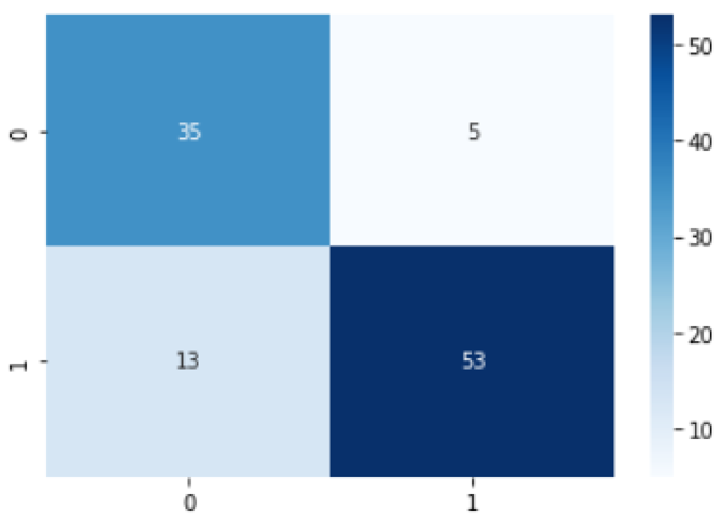
1.5) MultinomialHMM Without Tuning

```
Confusion Matrix:
[[35  5]
 [13 53]]
--------------------------------------------------
--------------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           b       0.73      0.88      0.80        40
           g       0.91      0.80      0.85        66

    accuracy                           0.83       106
   macro avg       0.82      0.84      0.83       106
weighted avg       0.84      0.83      0.83       106

--------------------------------------------------
--------------------------------------------------
Accuracy:
0.8301886792452831
```



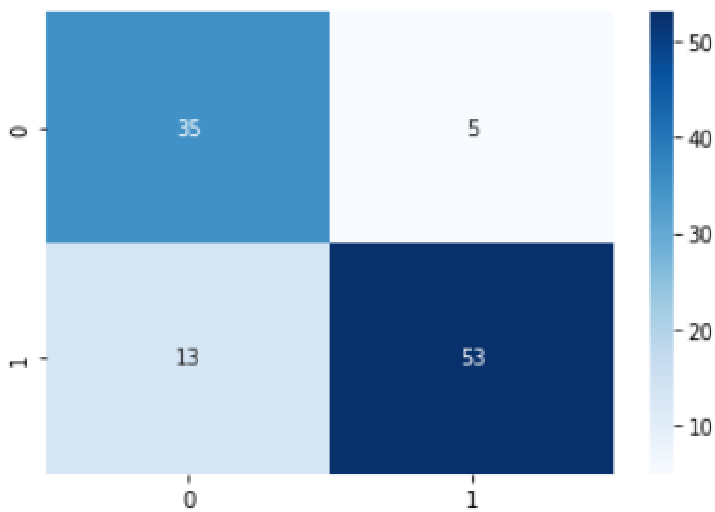
1.6) MultinomialHMM Without Tuning

```
Confusion Matrix:
[[35  5]
 [13 53]]
--------------------------------------------------
--------------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           b       0.73      0.88      0.80        40
           g       0.91      0.80      0.85        66

    accuracy                           0.83       106
   macro avg       0.82      0.84      0.83       106
weighted avg       0.84      0.83      0.83       106

--------------------------------------------------
--------------------------------------------------
Accuracy:
0.8301886792452831
```



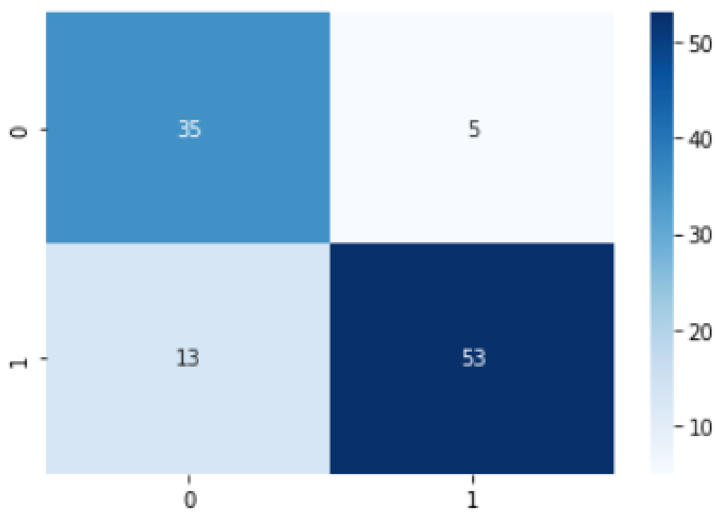
2.1) GaussianHMM Without Tuning

```
Confusion Matrix:
[[35  5]
 [13 53]]
--------------------------------------------------
--------------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           b       0.73      0.88      0.80        40
           g       0.91      0.80      0.85        66

    accuracy                           0.83       106
   macro avg       0.82      0.84      0.83       106
weighted avg       0.84      0.83      0.83       106

--------------------------------------------------
--------------------------------------------------
Accuracy:
0.8301886792452831
```



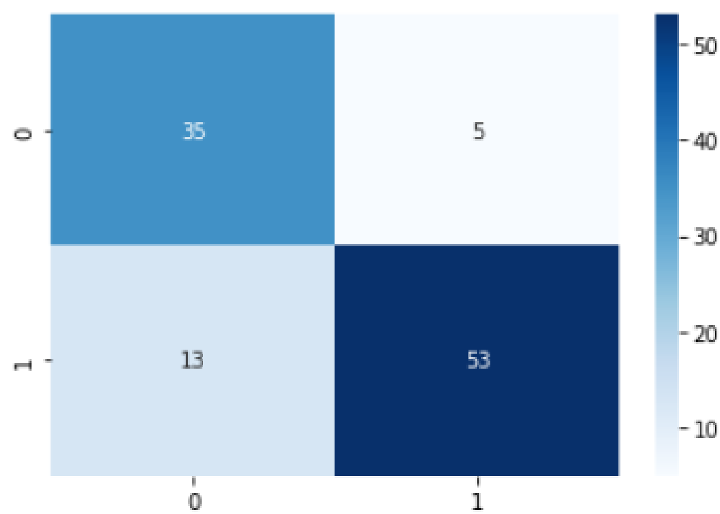
2.2) GaussianHMM With Tuning

```
Confusion Matrix:
[[35  5]
 [13 53]]
--------------------------------------------------
--------------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           b       0.73      0.88      0.80        40
           g       0.91      0.80      0.85        66

    accuracy                           0.83       106
   macro avg       0.82      0.84      0.83       106
weighted avg       0.84      0.83      0.83       106

--------------------------------------------------
--------------------------------------------------
Accuracy:
0.8301886792452831
```



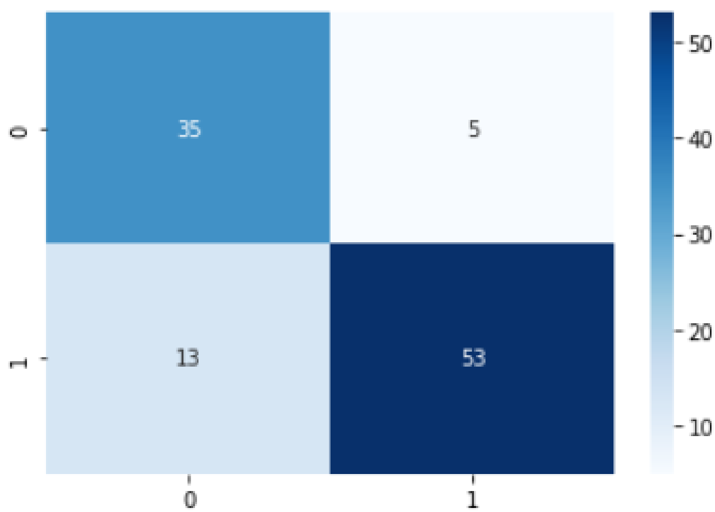
2.3) GMMHMM Without Tuning

```
Confusion Matrix:
[[35  5]
 [13 53]]
-------------------------------------------------
-------------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           b       0.73      0.88      0.80        40
           g       0.91      0.80      0.85        66

    accuracy                           0.83       106
   macro avg       0.82      0.84      0.83       106
weighted avg       0.84      0.83      0.83       106

-------------------------------------------------
-------------------------------------------------
Accuracy:
0.8301886792452831
```



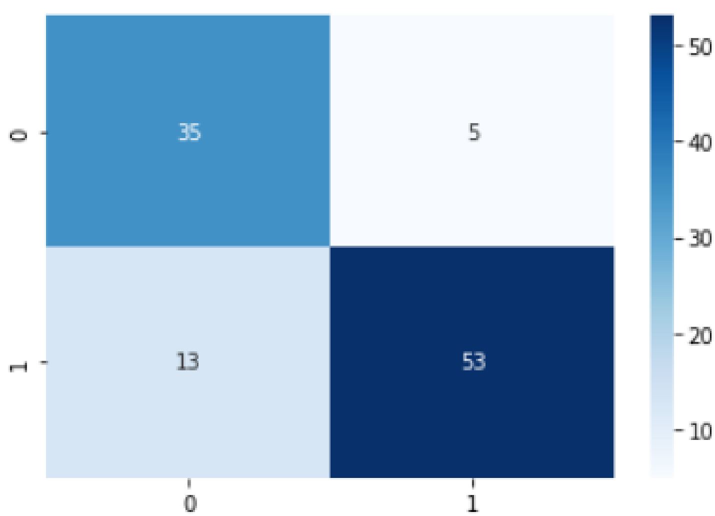
2.4) GMMHMM With Tuning

```
Confusion Matrix:
[[35  5]
 [13 53]]
--------------------------------------------------
--------------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           b       0.73      0.88      0.80        40
           g       0.91      0.80      0.85        66

    accuracy                           0.83       106
   macro avg       0.82      0.84      0.83       106
weighted avg       0.84      0.83      0.83       106

--------------------------------------------------
--------------------------------------------------
Accuracy:
0.8301886792452831
```



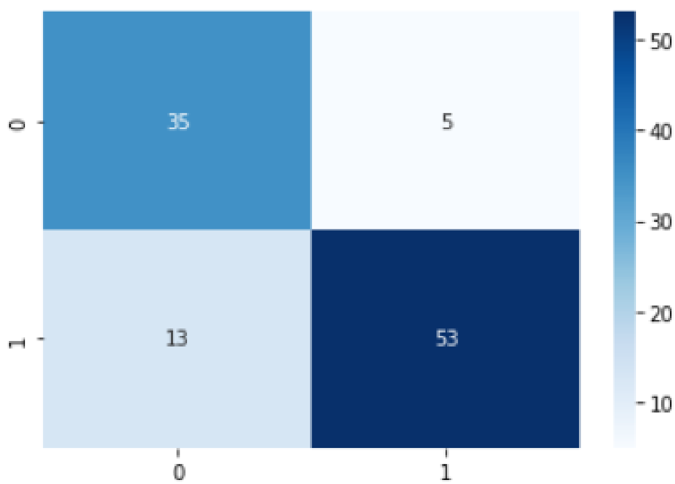
2.5) MultinomialHMM Without Tuning

```
Confusion Matrix:
[[35  5]
 [13 53]]
--------------------------------------------------
--------------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           b       0.73      0.88      0.80        40
           g       0.91      0.80      0.85        66

    accuracy                           0.83       106
   macro avg       0.82      0.84      0.83       106
weighted avg       0.84      0.83      0.83       106

--------------------------------------------------
--------------------------------------------------
Accuracy:
0.8301886792452831
```



2.6) MultinomialHMM Without Tuning

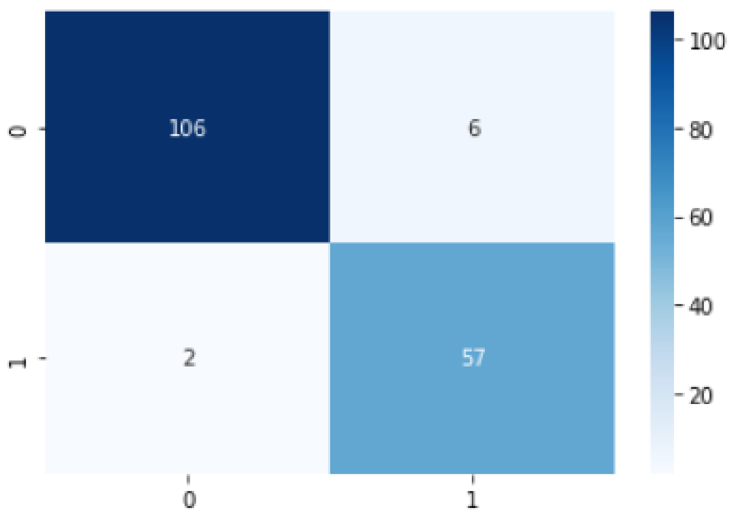
```
Confusion Matrix:
[[35  5]
 [13 53]]
-----------------------------------------------
-----------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           b       0.73      0.88      0.80        40
           g       0.91      0.80      0.85        66

    accuracy                           0.83       106
   macro avg       0.82      0.84      0.83       106
weighted avg       0.84      0.83      0.83       106

-----------------------------------------------
-----------------------------------------------
Accuracy:
0.8301886792452831
```



3) Breast Cancer Dataset

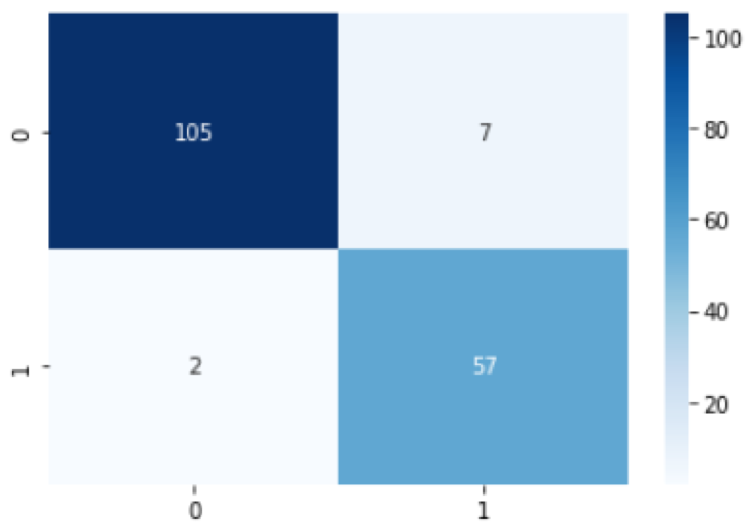
3.1) GaussianHMM Without Tuning

```
Confusion Matrix:
[[106   6]
 [  2  57]]
-------------------------------------------------
-------------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           B       0.98      0.95      0.96       112
           M       0.90      0.97      0.93        59

    accuracy                           0.95       171
   macro avg       0.94      0.96      0.95       171
weighted avg       0.96      0.95      0.95       171

-------------------------------------------------
-------------------------------------------------
Accuracy:
0.9532163742690059
```



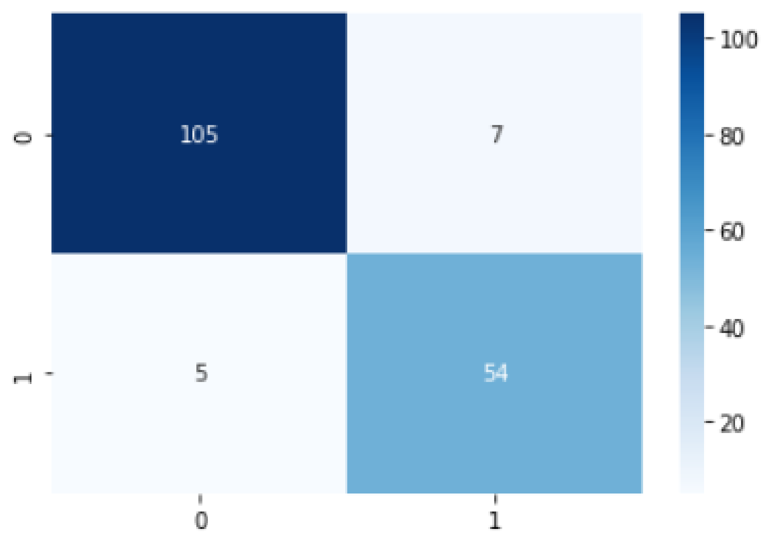
3.2) GaussianHMM With Tuning

```
Confusion Matrix:
[[105   7]
 [  2  57]]
--------------------------------------------------
--------------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           B       0.98      0.94      0.96       112
           M       0.89      0.97      0.93        59

    accuracy                           0.95       171
   macro avg       0.94      0.95      0.94       171
weighted avg       0.95      0.95      0.95       171

--------------------------------------------------
--------------------------------------------------
Accuracy:
0.9473684210526315
```



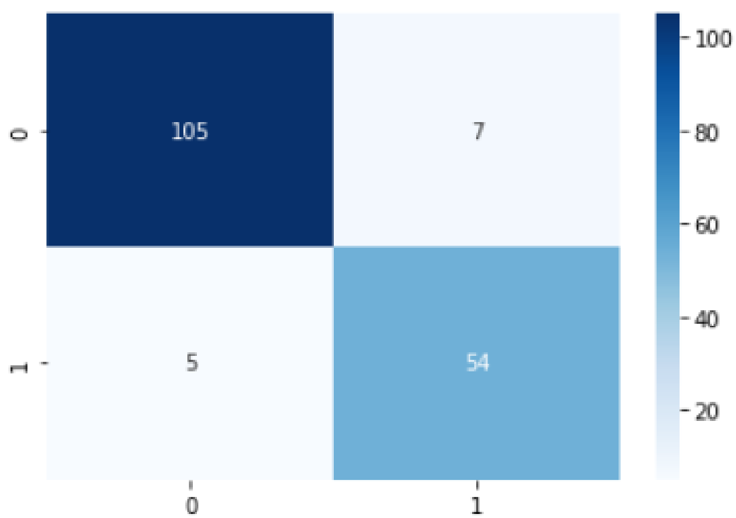
3.3) GMMHMM Without Tuning

```
Confusion Matrix:
[[105   7]
 [  5  54]]
--------------------------------------------------
--------------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           B       0.95      0.94      0.95       112
           M       0.89      0.92      0.90        59

    accuracy                           0.93       171
   macro avg       0.92      0.93      0.92       171
weighted avg       0.93      0.93      0.93       171

--------------------------------------------------
--------------------------------------------------
Accuracy:
0.9298245614035088
```



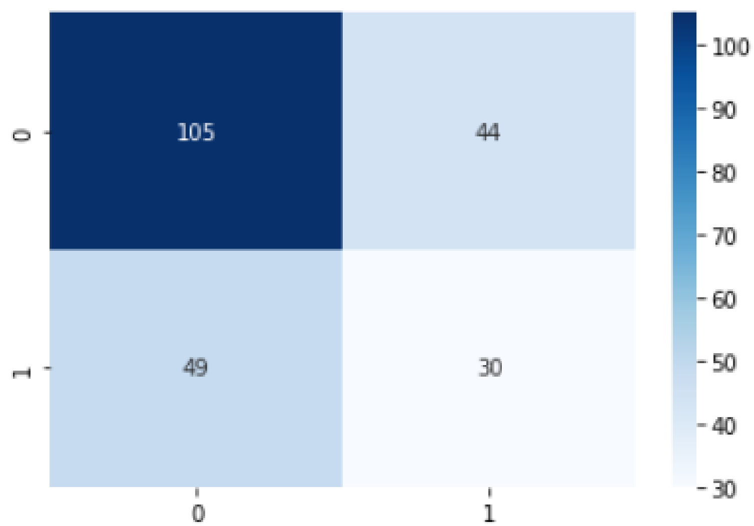
3.4) GMMHMM With Tuning

```
Confusion Matrix:
[[105   7]
 [  5  54]]
--------------------------------------------------
--------------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           B       0.95      0.94      0.95       112
           M       0.89      0.92      0.90        59

    accuracy                           0.93       171
   macro avg       0.92      0.93      0.92       171
weighted avg       0.93      0.93      0.93       171

--------------------------------------------------
--------------------------------------------------
Accuracy:
0.9298245614035088
```



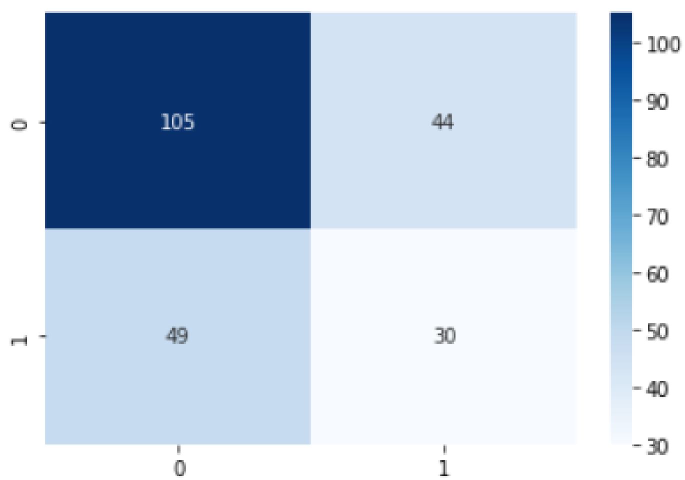
3.5) MultinomialHMM Without Tuning

```
Confusion Matrix:
[[105  44]
 [ 49  30]]
--------------------------------------------------
--------------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           B       0.68      0.70      0.69       149
           M       0.41      0.38      0.39        79

    accuracy                           0.59       228
   macro avg       0.54      0.54      0.54       228
weighted avg       0.59      0.59      0.59       228

--------------------------------------------------
--------------------------------------------------
Accuracy:
0.5921052631578947
```



3.6) MultinomialHMM Without Tuning

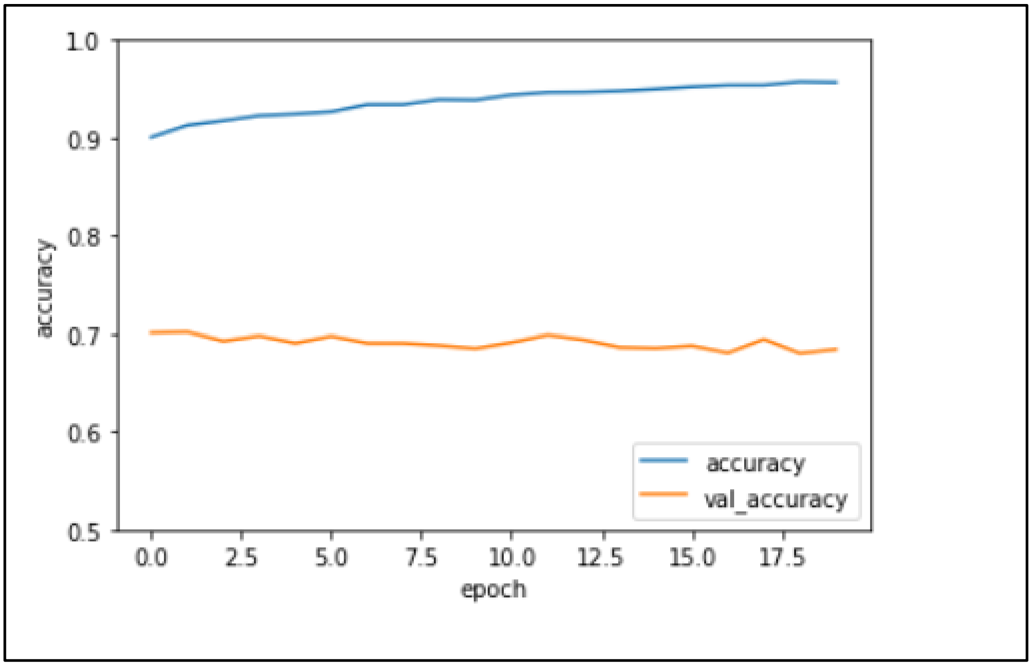
```
Confusion Matrix:
[[105  44]
 [ 49  30]]
--------------------------------------------------
--------------------------------------------------
Performance Evaluation
              precision    recall  f1-score   support

           B       0.68      0.70      0.69       149
           M       0.41      0.38      0.39        79

    accuracy                           0.59       228
   macro avg       0.54      0.54      0.54       228
weighted avg       0.59      0.59      0.59       228

--------------------------------------------------
--------------------------------------------------
Accuracy:
0.5921052631578947
```



1) CIFAR-10

```
Model: "sequential_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_6 (Conv2D)            (None, 30, 30, 32)        896
_________________________________________________________________
max_pooling2d_4 (MaxPooling2 (None, 15, 15, 32)        0
_________________________________________________________________
conv2d_7 (Conv2D)            (None, 13, 13, 64)        18496
_________________________________________________________________
max_pooling2d_5 (MaxPooling2 (None, 6, 6, 64)          0
_________________________________________________________________
conv2d_8 (Conv2D)            (None, 4, 4, 64)          36928
_________________________________________________________________
flatten (Flatten)            (None, 1024)              0
_________________________________________________________________
dense (Dense)                (None, 64)                65600
_________________________________________________________________
dense_1 (Dense)              (None, 10)                650
=================================================================
Total params: 122,570
Trainable params: 122,570
Non-trainable params: 0
_________________________________________________________________
```

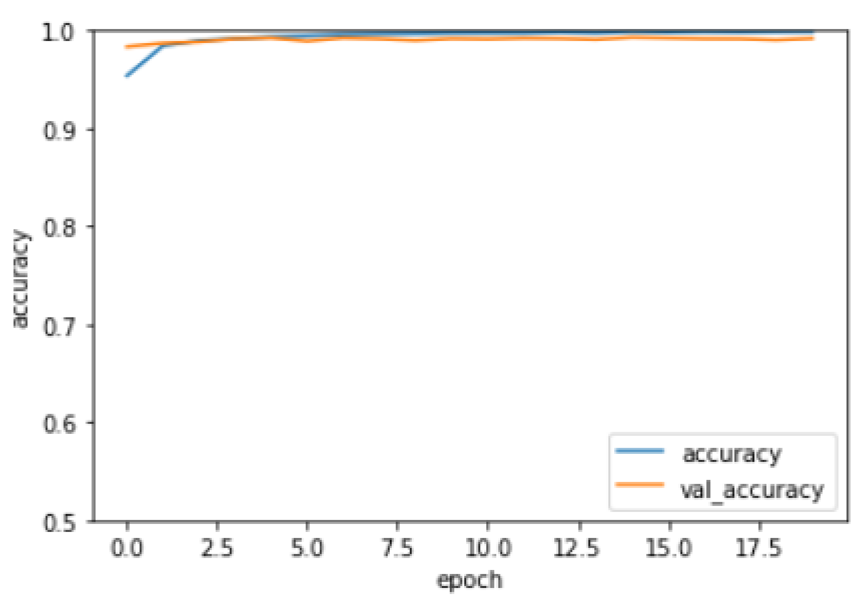
```
Epoch 11/20
1563/1563 [==============================] - 69s 44ms/step - loss: 0.1561 - accuracy: 0.9437 - val_loss: 1.8716 - val_accuracy: 0.6910
Epoch 12/20
1563/1563 [==============================] - 69s 44ms/step - loss: 0.1498 - accuracy: 0.9463 - val_loss: 1.9775 - val_accuracy: 0.6986
Epoch 13/20
1563/1563 [==============================] - 69s 44ms/step - loss: 0.1524 - accuracy: 0.9466 - val_loss: 2.0503 - val_accuracy: 0.6936
Epoch 14/20
1563/1563 [==============================] - 69s 44ms/step - loss: 0.1490 - accuracy: 0.9477 - val_loss: 2.0715 - val_accuracy: 0.6861
Epoch 15/20
1563/1563 [==============================] - 69s 44ms/step - loss: 0.1429 - accuracy: 0.9497 - val_loss: 2.1616 - val_accuracy: 0.6852
Epoch 16/20
1563/1563 [==============================] - 69s 44ms/step - loss: 0.1356 - accuracy: 0.9520 - val_loss: 2.2363 - val_accuracy: 0.6877
Epoch 17/20
1563/1563 [==============================] - 69s 44ms/step - loss: 0.1327 - accuracy: 0.9537 - val_loss: 2.2239 - val_accuracy: 0.6806
Epoch 18/20
1563/1563 [==============================] - 69s 44ms/step - loss: 0.1348 - accuracy: 0.9538 - val_loss: 2.2102 - val_accuracy: 0.6943
Epoch 19/20
1563/1563 [==============================] - 69s 44ms/step - loss: 0.1250 - accuracy: 0.9571 - val_loss: 2.3900 - val_accuracy: 0.6802
Epoch 20/20
1563/1563 [==============================] - 69s 44ms/step - loss: 0.1245 - accuracy: 0.9565 - val_loss: 2.3173 - val_accuracy: 0.6842
```



2) MNIST

```
Model: "sequential_8"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_18 (Conv2D)           (None, 26, 26, 32)        320
_________________________________________________________________
max_pooling2d_10 (MaxPooling (None, 13, 13, 32)        0
_________________________________________________________________
conv2d_19 (Conv2D)           (None, 11, 11, 64)        18496
_________________________________________________________________
max_pooling2d_11 (MaxPooling (None, 5, 5, 64)          0
_________________________________________________________________
conv2d_20 (Conv2D)           (None, 3, 3, 64)          36928
_________________________________________________________________
flatten_3 (Flatten)          (None, 576)               0
_________________________________________________________________
dense_6 (Dense)              (None, 64)                36928
_________________________________________________________________
dense_7 (Dense)              (None, 10)                650
=================================================================
Total params: 93,322
Trainable params: 93,322
Non-trainable params: 0
_________________________________________________________________
```

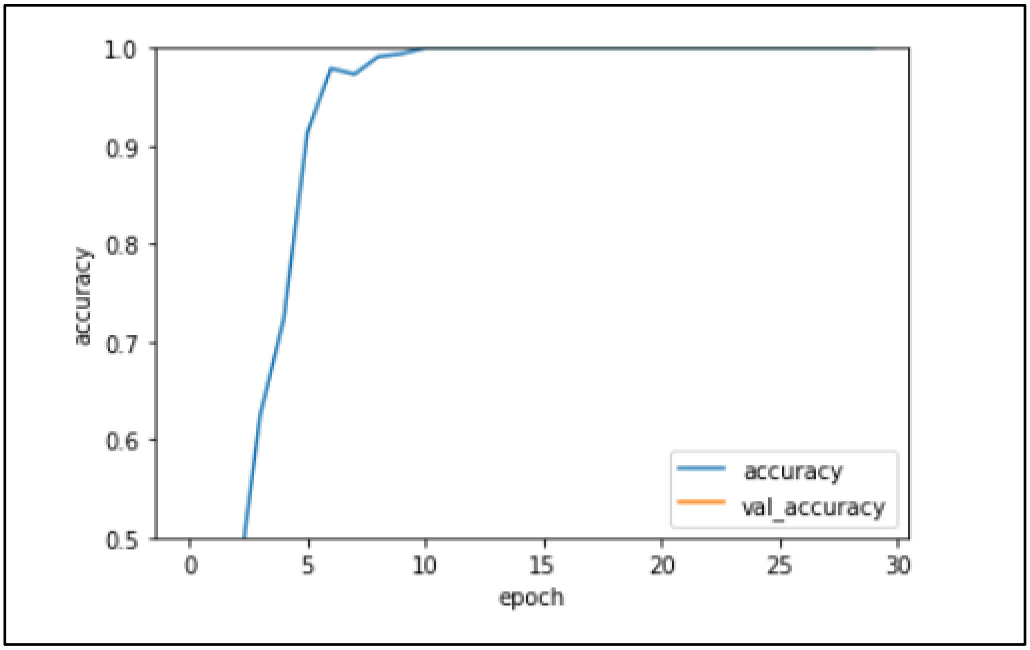
```
1875/1875 [==============================] - 57s 30ms/step - loss: 0.0079 - accuracy: 0.9973 - val_loss: 0.0319 - val_accuracy: 0.9913
Epoch 12/20
1875/1875 [==============================] - 57s 31ms/step - loss: 0.0084 - accuracy: 0.9973 - val_loss: 0.0329 - val_accuracy: 0.9921
Epoch 13/20
1875/1875 [==============================] - 57s 31ms/step - loss: 0.0067 - accuracy: 0.9980 - val_loss: 0.0343 - val_accuracy: 0.9918
Epoch 14/20
1875/1875 [==============================] - 58s 31ms/step - loss: 0.0078 - accuracy: 0.9973 - val_loss: 0.0390 - val_accuracy: 0.9908
Epoch 15/20
1875/1875 [==============================] - 58s 31ms/step - loss: 0.0048 - accuracy: 0.9985 - val_loss: 0.0374 - val_accuracy: 0.9930
Epoch 16/20
1875/1875 [==============================] - 58s 31ms/step - loss: 0.0069 - accuracy: 0.9980 - val_loss: 0.0336 - val_accuracy: 0.9923
Epoch 17/20
1875/1875 [==============================] - 57s 31ms/step - loss: 0.0049 - accuracy: 0.9985 - val_loss: 0.0430 - val_accuracy: 0.9916
Epoch 18/20
1875/1875 [==============================] - 57s 31ms/step - loss: 0.0053 - accuracy: 0.9982 - val_loss: 0.0397 - val_accuracy: 0.9915
Epoch 19/20
1875/1875 [==============================] - 58s 31ms/step - loss: 0.0048 - accuracy: 0.9986 - val_loss: 0.0540 - val_accuracy: 0.9903
Epoch 20/20
1875/1875 [==============================] - 58s 31ms/step - loss: 0.0043 - accuracy: 0.9987 - val_loss: 0.0419 - val_accuracy: 0.9919
```



3) SAVEE

```
Model: "sequential_3"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_9 (Conv2D)            (None, 155, 318, 32)      320
_________________________________________________________________
max_pooling2d_6 (MaxPooling2 (None, 77, 159, 32)       0
_________________________________________________________________
conv2d_10 (Conv2D)           (None, 75, 157, 64)       18496
_________________________________________________________________
max_pooling2d_7 (MaxPooling2 (None, 37, 78, 64)        0
_________________________________________________________________
conv2d_11 (Conv2D)           (None, 35, 76, 64)        36928
_________________________________________________________________
flatten_3 (Flatten)          (None, 170240)            0
_________________________________________________________________
dense_6 (Dense)              (None, 64)                10895424
_________________________________________________________________
dense_7 (Dense)              (None, 10)                650
=================================================================
Total params: 10,951,818
Trainable params: 10,951,818
Non-trainable params: 0
_________________________________________________________________
```

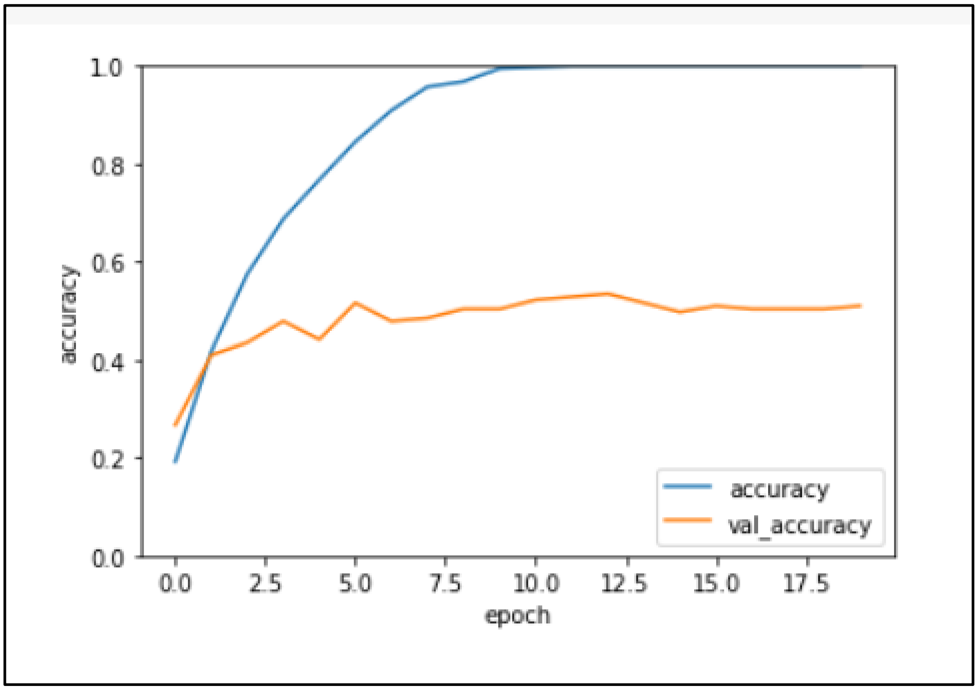
```
11/11 [==============================] - 27s 2s/step - loss: 2.2025e-05 - accuracy: 1.0000 - val_loss: 7.0087 - val_accuracy: 0.3056
Epoch 25/30
11/11 [==============================] - 27s 2s/step - loss: 1.9328e-05 - accuracy: 1.0000 - val_loss: 7.0391 - val_accuracy: 0.2986
Epoch 26/30
11/11 [==============================] - 27s 2s/step - loss: 1.7196e-05 - accuracy: 1.0000 - val_loss: 7.0967 - val_accuracy: 0.2986
Epoch 27/30
11/11 [==============================] - 27s 2s/step - loss: 1.5431e-05 - accuracy: 1.0000 - val_loss: 7.1239 - val_accuracy: 0.3056
Epoch 28/30
11/11 [==============================] - 27s 2s/step - loss: 1.3852e-05 - accuracy: 1.0000 - val_loss: 7.1493 - val_accuracy: 0.2986
Epoch 29/30
11/11 [==============================] - 27s 2s/step - loss: 1.2641e-05 - accuracy: 1.0000 - val_loss: 7.2041 - val_accuracy: 0.2986
Epoch 30/30
11/11 [==============================] - 27s 2s/step - loss: 1.1668e-05 - accuracy: 1.0000 - val_loss: 7.2112 - val_accuracy: 0.2986
```



4) EmoDB

```
Model: "sequential_4"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv2d_12 (Conv2D)           (None, 155, 318, 32)      320       
_________________________________________________________________
max_pooling2d_8 (MaxPooling2 (None, 77, 159, 32)       0         
_________________________________________________________________
conv2d_13 (Conv2D)           (None, 75, 157, 64)       18496     
_________________________________________________________________
max_pooling2d_9 (MaxPooling2 (None, 37, 78, 64)        0         
_________________________________________________________________
conv2d_14 (Conv2D)           (None, 35, 76, 64)        36928     
_________________________________________________________________
flatten_4 (Flatten)          (None, 170240)            0         
_________________________________________________________________
dense_8 (Dense)              (None, 64)                10895424  
_________________________________________________________________
dense_9 (Dense)              (None, 10)                650       
=================================================================
Total params: 10,951,818
Trainable params: 10,951,818
Non-trainable params: 0
_________________________________________________________________
```

```
Epoch 14/20
12/12 [==============================] - 30s 2s/step - loss: 0.0012 - accuracy: 1.0000 - val_loss: 3.9037 - val_accuracy: 0.5155
Epoch 15/20
12/12 [==============================] - 30s 2s/step - loss: 7.0827e-04 - accuracy: 1.0000 - val_loss: 4.0446 - val_accuracy: 0.4969
Epoch 16/20
12/12 [==============================] - 30s 2s/step - loss: 4.9740e-04 - accuracy: 1.0000 - val_loss: 4.1150 - val_accuracy: 0.5093
Epoch 17/20
12/12 [==============================] - 30s 3s/step - loss: 3.8747e-04 - accuracy: 1.0000 - val_loss: 4.1542 - val_accuracy: 0.5031
Epoch 18/20
12/12 [==============================] - 30s 2s/step - loss: 3.0542e-04 - accuracy: 1.0000 - val_loss: 4.2023 - val_accuracy: 0.5031
Epoch 19/20
12/12 [==============================] - 31s 3s/step - loss: 2.5256e-04 - accuracy: 1.0000 - val_loss: 4.2239 - val_accuracy: 0.5031
Epoch 20/20
12/12 [==============================] - 30s 2s/step - loss: 2.1154e-04 - accuracy: 1.0000 - val_loss: 4.2753 - val_accuracy: 0.5093
```



1) VGG-16

1.1) CIFAR-10

```
Epoch 1/5
63/63 [==============================] - 97s 855ms/step - loss: nan - accuracy: 0.0985
Epoch 2/5
63/63 [==============================] - 47s 743ms/step - loss: nan - accuracy: 0.1010
Epoch 3/5
63/63 [==============================] - 47s 745ms/step - loss: nan - accuracy: 0.1010
Epoch 4/5
63/63 [==============================] - 47s 744ms/step - loss: nan - accuracy: 0.1010
Epoch 5/5
63/63 [==============================] - 47s 744ms/step - loss: nan - accuracy: 0.1010

[ ] model.evaluate(X_test_resized, y_test)

63/63 [==============================] - 14s 225ms/step - loss: nan - accuracy: 0.0980
[nan, 0.09799999743700027]
```

1.2) MNIST

```
Epoch 1/5
63/63 [==============================] - 71s 877ms/step - loss: 3.6193 - accuracy: 0.0885
Epoch 2/5
63/63 [==============================] - 48s 764ms/step - loss: 2.5311 - accuracy: 0.0990
Epoch 3/5
63/63 [==============================] - 48s 763ms/step - loss: 2.5246 - accuracy: 0.1105
Epoch 4/5
63/63 [==============================] - 48s 763ms/step - loss: 2.5036 - accuracy: 0.1040
Epoch 5/5
63/63 [==============================] - 48s 763ms/step - loss: 2.4806 - accuracy: 0.0965

model.evaluate(X_test_new, y_test)

63/63 [==============================] - 15s 233ms/step - loss: 2.6352 - accuracy: 0.1095
[2.6351511478424072, 0.10949999839067459]
```

1.3) SAVEE

```
8/8 [==============================] - 6s 708ms/step - loss: nan - accuracy: 0.1208
Epoch 45/50
8/8 [==============================] - 6s 706ms/step - loss: nan - accuracy: 0.1208
Epoch 46/50
8/8 [==============================] - 6s 705ms/step - loss: nan - accuracy: 0.1208
Epoch 47/50
8/8 [==============================] - 6s 706ms/step - loss: nan - accuracy: 0.1208
Epoch 48/50
8/8 [==============================] - 6s 709ms/step - loss: nan - accuracy: 0.1208
Epoch 49/50
8/8 [==============================] - 6s 706ms/step - loss: nan - accuracy: 0.1208
Epoch 50/50
8/8 [==============================] - 6s 706ms/step - loss: nan - accuracy: 0.1208
```

```
model.evaluate(X_test_resized, y_test)
```

```
8/8 [==============================] - 2s 215ms/step - loss: nan - accuracy: 0.1292
[nan, 0.12916666269302368]
```

1.4) EmoDB

```
9/9 [==============================] - 6s 711ms/step - loss: nan - accuracy: 0.2247
Epoch 14/20
9/9 [==============================] - 6s 712ms/step - loss: nan - accuracy: 0.2247
Epoch 15/20
9/9 [==============================] - 6s 713ms/step - loss: nan - accuracy: 0.2247
Epoch 16/20
9/9 [==============================] - 6s 712ms/step - loss: nan - accuracy: 0.2247
Epoch 17/20
9/9 [==============================] - 6s 712ms/step - loss: nan - accuracy: 0.2247
Epoch 18/20
9/9 [==============================] - 6s 711ms/step - loss: nan - accuracy: 0.2247
Epoch 19/20
9/9 [==============================] - 6s 712ms/step - loss: nan - accuracy: 0.2247
Epoch 20/20
9/9 [==============================] - 6s 712ms/step - loss: nan - accuracy: 0.2247
```

```
model.evaluate(X_test_resized, y_test)
```

```
9/9 [==============================] - 6s 718ms/step - loss: nan - accuracy: 0.2500
[nan, 0.25]
```

The entire model can be broken down into 5 blocks, where each block contains 3 convolution and 1 max-pooling layers.

Looking at the complexity of the model and the limitations of google colab, I have reduced the input size for the model,i.e., i have taken 2000 training data points and 2000 testing data points.

2) ResNet-50

2.1) CIFAR-10

```
Downloading data from https://github.com/fchollet/deep-learning-models/releases/download/v0.2/resnet5
102858752/102853048 [==============================] - 1s 0us/step
102866944/102853048 [==============================] - 1s 0us/step
Epoch 1/5
63/63 [==============================] - 81s 703ms/step - loss: 2.9229 - accuracy: 0.0975
Epoch 2/5
63/63 [==============================] - 42s 673ms/step - loss: 2.4506 - accuracy: 0.1040
Epoch 3/5
63/63 [==============================] - 42s 673ms/step - loss: 2.2995 - accuracy: 0.1755
Epoch 4/5
63/63 [==============================] - 42s 672ms/step - loss: 2.1401 - accuracy: 0.2325
Epoch 5/5
63/63 [==============================] - 42s 672ms/step - loss: 2.0272 - accuracy: 0.2715
```

```
model.evaluate(X_test_resized, y_test)
```

```
63/63 [==============================] - 15s 217ms/step - loss: 16.8393 - accuracy: 0.0000e+00
[16.839269638061523, 0.0]
```

2.2) MNIST

```
Epoch 6/10
63/63 [==============================] - 44s 705ms/step - loss: 0.0647 - accuracy: 0.9825
Epoch 7/10
63/63 [==============================] - 44s 705ms/step - loss: 0.0655 - accuracy: 0.9815
Epoch 8/10
63/63 [==============================] - 44s 705ms/step - loss: 0.0429 - accuracy: 0.9890
Epoch 9/10
63/63 [==============================] - 44s 705ms/step - loss: 0.0272 - accuracy: 0.9950
Epoch 10/10
63/63 [==============================] - 44s 704ms/step - loss: 0.0121 - accuracy: 0.9985
```

```
model.evaluate(X_test_new, y_test)
```

```
63/63 [==============================] - 14s 227ms/step - loss: 13.1569 - accuracy: 0.0000e+00
[13.156914710998535, 0.0]
```

2.3) SAVEE

```
8/8 [==============================] - 5s 669ms/step - loss: 1.0197 - accuracy: 0.6833
Epoch 5/10
8/8 [==============================] - 5s 667ms/step - loss: 0.5054 - accuracy: 0.9167
Epoch 6/10
8/8 [==============================] - 5s 669ms/step - loss: 0.2390 - accuracy: 0.9833
Epoch 7/10
8/8 [==============================] - 5s 671ms/step - loss: 0.0966 - accuracy: 1.0000
Epoch 8/10
8/8 [==============================] - 5s 668ms/step - loss: 0.0691 - accuracy: 1.0000
Epoch 9/10
8/8 [==============================] - 5s 669ms/step - loss: 0.0550 - accuracy: 1.0000
Epoch 10/10
8/8 [==============================] - 5s 666ms/step - loss: 0.0281 - accuracy: 1.0000
```

```
model.evaluate(X_test_resized, y_test)
```

```
8/8 [==============================] - 3s 215ms/step - loss: 8.7594 - accuracy: 0.0000e+00
[8.759380340576172, 0.0]
```

2.4) EmoDB

```
Epoch 3/10
9/9 [==============================] - 6s 663ms/step - loss: 1.1062 - accuracy: 0.6367
Epoch 4/10
9/9 [==============================] - 6s 661ms/step - loss: 0.6534 - accuracy: 0.7678
Epoch 5/10
9/9 [==============================] - 6s 662ms/step - loss: 0.3835 - accuracy: 0.8914
Epoch 6/10
9/9 [==============================] - 6s 662ms/step - loss: 0.3716 - accuracy: 0.8689
Epoch 7/10
9/9 [==============================] - 6s 662ms/step - loss: 0.2297 - accuracy: 0.9213
Epoch 8/10
9/9 [==============================] - 6s 661ms/step - loss: 0.1096 - accuracy: 0.9775
Epoch 9/10
9/9 [==============================] - 6s 664ms/step - loss: 0.1170 - accuracy: 0.9850
Epoch 10/10
9/9 [==============================] - 6s 659ms/step - loss: 0.2414 - accuracy: 0.9251
```

```
model.evaluate(X_test_resized, y_test)
```

```
9/9 [==============================] - 4s 304ms/step - loss: 7.2902 - accuracy: 0.0000e+00
[7.290168285369873, 0.0]
```

Looking at the complexity of the model and the limitations of google colab, I have reduced the input size for the model,i.e., I have taken 2000 training data points and 2000 testing data points.

3) Recurrent Neural Networks (RNN)

3.1) CIFAR-10

```
Epoch 3/10
200/200 [==============================] - 111s 557ms/step - loss: 2.0085 - accuracy: 0.2645
Epoch 4/10
200/200 [==============================] - 112s 558ms/step - loss: 1.9649 - accuracy: 0.2771
Epoch 5/10
200/200 [==============================] - 111s 557ms/step - loss: 1.9583 - accuracy: 0.2816
Epoch 6/10
200/200 [==============================] - 111s 557ms/step - loss: 1.9388 - accuracy: 0.2896
Epoch 7/10
200/200 [==============================] - 111s 557ms/step - loss: 1.9371 - accuracy: 0.2899
Epoch 8/10
200/200 [==============================] - 111s 556ms/step - loss: 1.9254 - accuracy: 0.2989
Epoch 9/10
200/200 [==============================] - 111s 557ms/step - loss: 1.9188 - accuracy: 0.2966
Epoch 10/10
200/200 [==============================] - 111s 556ms/step - loss: 1.9341 - accuracy: 0.2930

model.evaluate(test_images, test_labels)

157/157 [==============================] - 38s 225ms/step - loss: 1.9601 - accuracy: 0.2912
[1.9600898027420044, 0.29120001196861267]
```

3.2) MNIST

```
print('Test Accuracy of the model on the 10000 test images: {} %'.format(100 * correct / total))

Test Accuracy of the model on the 10000 test images: 97.77 %
```

3.3) SAVEE

```
[ ] model.evaluate(X_test, y_test)

    6/6 [==============================] - 2s 57ms/step - loss: 1.4087 - accuracy: 0.4323
    [1.408677577972412, 0.4322916567325592]
```

3.4) EmoDB

```
    8/8 [==============================] - 1s 130ms/step - loss: 0.2239 - accuracy: 0.9144
    Epoch 50/50
    8/8 [==============================] - 1s 127ms/step - loss: 0.2858 - accuracy: 0.8984

[ ] model.evaluate(X_test, y_test)

    6/6 [==============================] - 2s 54ms/step - loss: 1.7593 - accuracy: 0.5590
    [1.7592660188674927, 0.5590062141418457]
```

4) AlexNet

4.1) CIFAR-10

```
Epoch 1/5
16/16 [==============================] - 61s 4s/step - loss: 2.6788 - accuracy: 0.1240
Epoch 2/5
16/16 [==============================] - 59s 4s/step - loss: 2.6332 - accuracy: 0.0960
Epoch 3/5
16/16 [==============================] - 60s 4s/step - loss: 2.5360 - accuracy: 0.1220
Epoch 4/5
16/16 [==============================] - 59s 4s/step - loss: 2.4222 - accuracy: 0.1400
Epoch 5/5
16/16 [==============================] - 60s 4s/step - loss: 2.3684 - accuracy: 0.1400
```

```
[ ] model.evaluate(X_test_resized, y_test)
```

```
7/7 [==============================] - 6s 753ms/step - loss: 2.3611 - accuracy: 0.0750
[2.3610661029815674, 0.07500000298023224]
```

4.2) MNIST

```
Epoch 1/5
63/63 [==============================] - 474s 8s/step - loss: 2.0734 - accuracy: 0.2610
Epoch 2/5
63/63 [==============================] - 476s 8s/step - loss: 1.7821 - accuracy: 0.3680
Epoch 3/5
63/63 [==============================] - 468s 7s/step - loss: 1.6773 - accuracy: 0.4395
Epoch 4/5
63/63 [==============================] - 469s 7s/step - loss: 1.5820 - accuracy: 0.4810
Epoch 5/5
63/63 [==============================] - 472s 7s/step - loss: 1.5318 - accuracy: 0.5040
```

```
[ ] model.evaluate(X_test_new, y_test)
```

```
63/63 [==============================] - 107s 2s/step - loss: 2.3417 - accuracy: 0.1170
[2.3417277336120605, 0.11699999868869781]
```

4.3) SAVEE

```
Epoch 4/10
8/8 [==============================] - 56s 7s/step - loss: 2.4215 - accuracy: 0.1583
Epoch 5/10
8/8 [==============================] - 56s 7s/step - loss: 2.2042 - accuracy: 0.2333
Epoch 6/10
8/8 [==============================] - 57s 7s/step - loss: 2.2080 - accuracy: 0.2042
Epoch 7/10
8/8 [==============================] - 56s 7s/step - loss: 2.1114 - accuracy: 0.2792
Epoch 8/10
8/8 [==============================] - 57s 7s/step - loss: 2.1120 - accuracy: 0.2542
Epoch 9/10
8/8 [==============================] - 56s 7s/step - loss: 2.0292 - accuracy: 0.2583
Epoch 10/10
8/8 [==============================] - 57s 7s/step - loss: 2.1150 - accuracy: 0.2417
```

```
model.evaluate(X_test_resized, y_test)
```

```
8/8 [==============================] - 13s 2s/step - loss: 2.2758 - accuracy: 0.2375
[2.275780200958252, 0.23749999701976776]
```

4.4) EmoDB

```
11/11 [==============================] - 75s 7s/step - loss: 2.2610 - accuracy: 0.1838
Epoch 6/10
11/11 [==============================] - 75s 7s/step - loss: 2.1741 - accuracy: 0.2025
Epoch 7/10
11/11 [==============================] - 77s 7s/step - loss: 2.0738 - accuracy: 0.2336
Epoch 8/10
11/11 [==============================] - 76s 7s/step - loss: 2.0492 - accuracy: 0.2679
Epoch 9/10
11/11 [==============================] - 76s 7s/step - loss: 2.0359 - accuracy: 0.2679
Epoch 10/10
11/11 [==============================] - 76s 7s/step - loss: 1.9726 - accuracy: 0.3115
```

```
model.evaluate(X_test_resized, y_test)
```

```
7/7 [==============================] - 12s 2s/step - loss: 2.1748 - accuracy: 0.2336
[2.1748006343841553, 0.23364485800266266]
```

Looking at the complexity of the model and the limitations of google colab, I have reduced the input size for the model,i.e., I have taken 2000 training data points and 2000 testing data points.

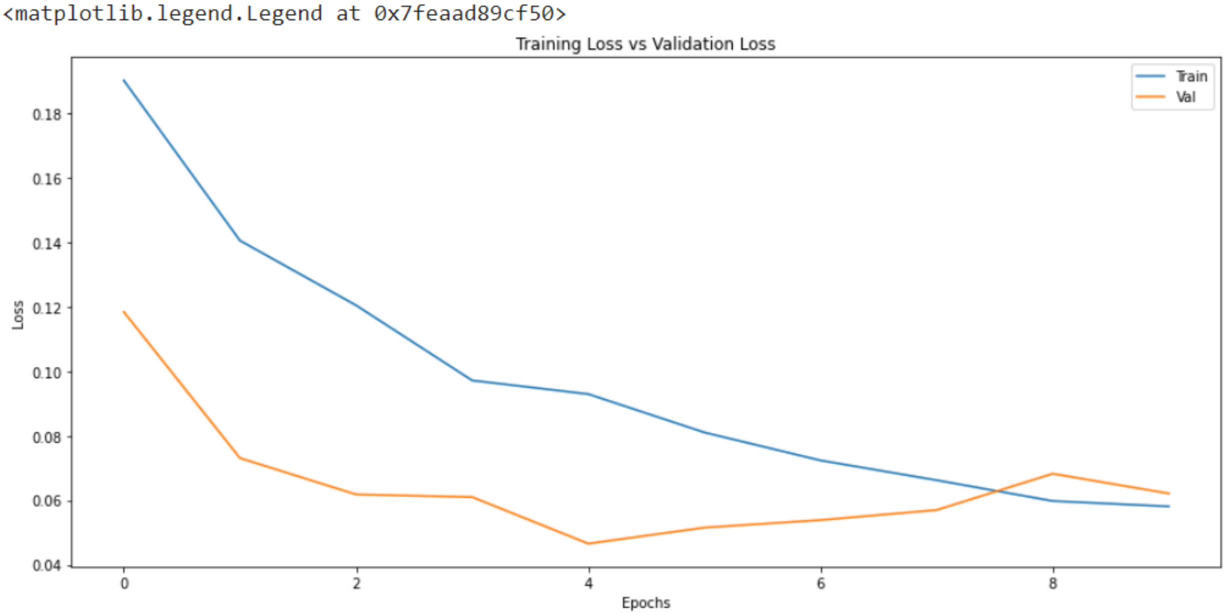
5) GoogLeNet

5.1) CIFAR-10

```
output_2_loss: 2.0650 - val_output_accuracy: 0.2305 - val_auxilliary_output_1_accuracy: 0.2400 - val_auxilliary_output_2_accuracy: 0.2240

output_2_loss: 2.0244 - val_output_accuracy: 0.2470 - val_auxilliary_output_1_accuracy: 0.2630 - val_auxilliary_output_2_accuracy: 0.2585

output_2_loss: 2.0076 - val_output_accuracy: 0.2355 - val_auxilliary_output_1_accuracy: 0.2735 - val_auxilliary_output_2_accuracy: 0.2660
```

5.2) MNIST

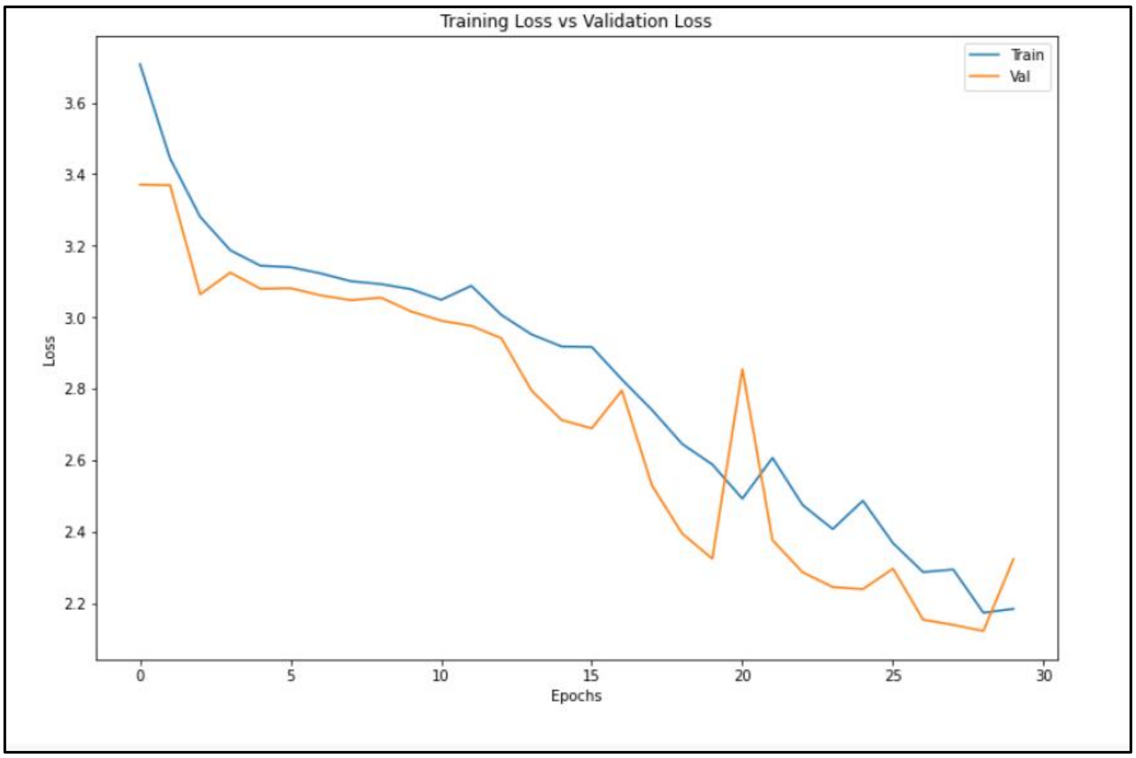
```
<matplotlib.legend.Legend at 0x7feaad89cf50>
```



```
model.evaluate(x_test, y_test)
```

```
313/313 [==============================] - 24s 6
[0.05425573140382767,
 0.03818700090050697,
 0.02569129876792431,
 0.027871087193489075,
 0.9873999953269958,
 0.9926000237464905,
 0.9902999997138977]
```

5.3) SAVEE



```
model.evaluate(X_test, y_test)

6/6 [=============================]
[2.324364423751831,
 1.458065390586853,
 1.4511628150939941,
 1.4365006685256958,
 0.3541666567325592,
 0.3333333432674408,
 0.3802083432674408]
```

5.4) EmoDB

```
model.evaluate(X_test, y_test)

7/7 [==============================]
[2.8008506298065186,
 1.7843737602233887,
 1.6508854627609253,
 1.7373706102371216,
 0.30841121077537537,
 0.38785046339035034,
 0.3644859790802002]
```

Hidden Markov Model (HMM)

Dataset	Classifier	Train-Test Ratio	Precision	Recall	F1-Score	Support	Accuracy
Wine Dataset	GaussianHMM(With Tuning)	70-30	0.82	0.84	0.83	106	83
	GaussianHMM(With Tuning)	60-40	0.8	0.81	0.8	141	0.8
	GaussianHMM(With Tuning)	50-50	0.74	0.75	0.74	176	0.75
	GaussianHMM(With Tuning)	40-60	0.68	0.69	0.68	211	0.69
	GaussianHMM(With Tuning)	30-70	0.49	0.5	0.49	246	57
	GaussianHMM(Without Tuning)	70-30	0.91	0.95	0.93	54	92
	GaussianHMM(Without Tuning)	60-40	0.97	0.98	0.97	72	97

	GaussianHMM(Without Tuning)	50-50	0.34	0.35	0.34	89	35
	GaussianHMM(Without Tuning)	40-60	0.95	0.95	0.95	107	94
	GaussianHMM(Without Tuning)	30-70	0.33	0.39	0.36	125	37
	GMMHMM(With Tuning)	70-30	0.82	0.84	0.83	106	83
	GMMHMM(With Tuning)	60-40	0.8	0.81	0.8	141	0.8
	GMMHMM(With Tuning)	50-50	0.74	0.75	0.74	176	0.75
	GMMHMM(With Tuning)	40-60	0.68	0.69	0.68	211	0.69
	GMMHMM(With Tuning)	30-70	0.49	0.5	0.49	246	57
	GMMHMM(Without Tuning)	70-30	0.91	0.95	0.93	54	92
	GMMHMM(Without Tuning)	60-40	0.97	0.98	0.97	72	97
	GMMHMM(Without Tuning)	50-50	0.95	0.95	0.95	89	94
	GMMHMM(Without Tuning)	40-60	0.94	0.94	0.94	107	93
	GMMHMM(Without Tuning)	30-70	0.05	0.04	0.05	125	4.8
	MultinomialHMM(With Tuning)	70-30	0.82	0.84	0.83	106	83
	MultinomialHMM(With Tuning)	60-40	0.83	0.84	0.83	141	83
	MultinomialHMM(With Tuning)	50-50	0.74	0.75	0.74	176	75
	MultinomialHMM(With Tuning)	40-60	0.69	0.69	0.69	211	71

	MultinomialHMM(With Tuning)	30-70	0.52	0.51	0.43	246	43
	MultinomialHMM(Without Tuning)	70-30	0.82	0.84	0.83	106	83
	MultinomialHMM(Without Tuning)	60-40	0.83	0.84	0.83	141	83
	MultinomialHMM(Without Tuning)	50-50	0.74	0.75	0.74	176	75
	MultinomialHMM(Without Tuning)	40-60	0.69	0.69	0.69	211	71
	MultinomialHMM(Without Tuning)	30-70	0.52	0.51	0.43	246	0.43
Ionosphere Dataset	GaussianHMM(With Tuning)	70-30	0.82	0.84	0.83	106	83
	GaussianHMM(With Tuning)	60-40	0.8	0.81	0.8	141	0.8
	GaussianHMM(With Tuning)	50-50	0.74	0.75	0.74	176	0.75
	GaussianHMM(With Tuning)	40-60	0.68	0.69	0.68	211	0.69
	GaussianHMM(With Tuning)	30-70	0.49	0.5	0.49	246	57
	GaussianHMM(Without Tuning)	70-30	0.82	0.84	0.83	106	83
	GaussianHMM(Without Tuning)	60-40	0.81	0.82	0.81	141	81
	GaussianHMM(Without Tuning)	50-50	0.74	0.75	0.74	176	75
	GaussianHMM(Without Tuning)	40-60	0.68	0.69	0.68	211	69
	GaussianHMM(Without Tuning)	30-70	0.75	0.78	0.73	246	73
	GMMHMM(With Tuning)	70-30	0.82	0.84	0.83	106	83

	GMMHMM(With Tuning)	60-40	0.83	0.84	0.83	141	83
	GMMHMM(With Tuning)	50-50	0.74	0.75	0.74	176	75
	GMMHMM(With Tuning)	40-60	0.69	0.69	0.69	211	71
	GMMHMM(With Tuning)	30-70	0.52	0.51	0.43	246	43
	GMMHMM(Without Tuning)	70-30	0.82	0.84	0.83	106	83
	GMMHMM(Without Tuning)	60-40	0.83	0.84	0.83	141	83
	GMMHMM(Without Tuning)	50-50	0.74	0.75	0.74	176	75
	GMMHMM(Without Tuning)	40-60	0.69	0.69	0.69	211	71
	GMMHMM(Without Tuning)	30-70	0.52	0.51	0.43	246	0.43
	MultinomialHMM(With Tuning)	70-30	0.82	0.84	0.83	106	83
	MultinomialHMM(With Tuning)	60-40	0.83	0.84	0.83	141	83
	MultinomialHMM(With Tuning)	50-50	0.74	0.75	0.74	176	75
	MultinomialHMM(With Tuning)	40-60	0.69	0.69	0.69	211	71
	MultinomialHMM(With Tuning)	30-70	0.52	0.51	0.43	246	43
	MultinomialHMM(Without Tuning)	70-30	0.82	0.84	0.83	106	83
	MultinomialHMM(Without Tuning)	60-40	0.83	0.84	0.83	141	83
	MultinomialHMM(Without Tuning)	50-50	0.74	0.75	0.74	176	75

	MultinomialHMM(Without Tuning)	40-60	0.69	0.69	0.69	211	71
	MultinomialHMM(Without Tuning)	30-70	0.52	0.51	0.43	246	0.43
Breast Cancer Dataset	GaussianHMM(With Tuning)	70-30	0.94	0.95	0.94	171	94
	GaussianHMM(With Tuning)	60-40	0.94	0.95	0.94	228	94
	GaussianHMM(With Tuning)	50-50	0.07	0.06	0.06	285	6
	GaussianHMM(With Tuning)	40-60	0.85	0.84	0.84	342	86
	GaussianHMM(With Tuning)	30-70	0.91	0.91	0.91	399	91
	GaussianHMM(Without Tuning)	70-30	0.94	0.96	0.95	171	95
	GaussianHMM(Without Tuning)	60-40	0.92	0.93	0.92	228	92
	GaussianHMM(Without Tuning)	50-50	0.93	0.94	0.93	285	93
	GaussianHMM(Without Tuning)	40-60	0.85	0.84	0.84	342	86
	GaussianHMM(Without Tuning)	30-70	0.91	0.91	0.91	399	91
	GMMHMM(With Tuning)	70-30	0.92	0.93	0.92	171	92
	GMMHMM(With Tuning)	60-40	0.91	0.91	0.91	228	91
	GMMHMM(With Tuning)	50-50	0.91	0.92	0.91	285	91
	GMMHMM(With Tuning)	40-60	0.89	0.91	0.9	342	90
	GMMHMM(With Tuning)	30-70	0.9	0.78	0.8	399	0.83

	GMMHMM(Without Tuning)	70-30	0.92	0.93	0.92	171	92
	GMMHMM(Without Tuning)	60-40	0.91	0.91	0.91	228	91
	GMMHMM(Without Tuning)	50-50	0.91	0.92	0.91	285	91
	GMMHMM(Without Tuning)	40-60	0.89	0.91	0.9	342	90
	GMMHMM(Without Tuning)	30-70	0.9	0.91	0.9	399	90
	MultinomialHMM(With Tuning)	70-30	0.51	0.51	0.51	171	57
	MultinomialHMM(With Tuning)	60-40	0.54	0.54	0.54	228	59
	MultinomialHMM(With Tuning)	50-50	0.54	0.54	0.54	285	57
	MultinomialHMM(With Tuning)	40-60	0.53	0.53	0.53	342	58
	MultinomialHMM(With Tuning)	30-70	0.54	0.54	0.54	399	57
	MultinomialHMM(Without Tuning)	70-30	0.51	0.51	0.51	171	57
	MultinomialHMM(Without Tuning)	60-40	0.54	0.54	0.54	228	59
	MultinomialHMM(Without Tuning)	50-50	0.54	0.54	0.54	285	57
	MultinomialHMM(Without Tuning)	40-60	0.53	0.53	0.53	342	58
	MultinomialHMM(Without Tuning)	30-70	0.54	0.54	0.54	399	57

Convolutional Neural Networks(CNN)							
Dataset	**Accuracy**						
CIFAR-10	68						
MNIST	99						
SAVEE	29						
EmoDB	50						
Other Deep Learning Models							
Models	**Dataset**	**Accuracy**					
VGG-16	CIFAR-10	9.8					
	MNIST	10.95					
	SAVEE	12.92					
	EmoDB	25					
ResNet-50	CIFAR-10	27					
	MNIST	99					
	SAVEE	99					
	EmoDB	92					
Recurrent Neural Networks (RNN)	CIFAR-10	29					
	MNIST	97					
	SAVEE	43					
	EmoDB	55					
AlexNet	CIFAR-10	7.5					
	MNIST	11.69					

	SAVEE	23.74					
	EmoDB	23.36					
GoogLeNet	CIFAR-10	26.6					
	MNIST	99					
	SAVEE	38					
	EmoDB	36					

```
# WINE DATASET
# GaussianHMM(Without Tuning)[70-30 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wine.data",header=None)

col_name = ['Class','Alcohol','Malic acid','Ash','Alcalinity of
ash','Magnesium','Total phenols','Flavanoids',
        'Nonflavanoid phenols','Proanthocyanins','Color
intensity','Hue','OD280/OD315 of diluted wines','Proline']


df.columns = col_name


X = df.drop(['Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split
```

```
X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.7,test_size=0.3,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=3, covariance_type="full")
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
	if y_pred[i] == 0:
	strings[i] = 1
	elif y_pred[i] == 1:
	strings[i] = 2
	else:
	strings[i] = 3

strings = strings.astype(np.int)
```

```
from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-----------------------------------------")
print("-----------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-----------------------------------------")
print("-----------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# WINE DATASET
# GaussianHMM(Without Tuning)[60-40 split]
```

```
import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wine.data",header=None)

col_name = ['Class','Alcohol','Malic acid','Ash','Alcalinity of
ash','Magnesium','Total phenols','Flavanoids',
        'Nonflavanoid phenols','Proanthocyanins','Color
intensity','Hue','OD280/OD315 of diluted wines','Proline']


df.columns = col_name


X = df.drop(['Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.6,test_size=0.4,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
```

```
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=3, covariance_type="full")
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 0:
        strings[i] = 1
        elif y_pred[i] == 1:
        strings[i] = 2
        else:
        strings[i] = 3

strings = strings.astype(np.int)



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-------------------------------------------------")
print("-------------------------------------------------")
```

```
print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-----------------------------------------------")
print("-----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# WINE DATASET
# GaussianHMM(Without Tuning)[50-50 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wine.data",header=None)

col_name = ['Class','Alcohol','Malic acid','Ash','Alcalinity of
ash','Magnesium','Total phenols','Flavanoids',
        'Nonflavanoid phenols','Proanthocyanins','Color
intensity','Hue','OD280/OD315 of diluted wines','Proline']
```

```
df.columns = col_name


X = df.drop(['Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.5,test_size=0.5,random_state=None)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=3, covariance_type="full")
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
	if y_pred[i] == 0:
```

```
        strings[i] = 1
        elif y_pred[i] == 1:
        strings[i] = 2
        else:
        strings[i] = 3

strings = strings.astype(np.int)



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("----------------------------------------------------")
print("----------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("----------------------------------------------------")
print("----------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
```

```
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# WINE DATASET
# GaussianHMM(Without Tuning)[40-60 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wine.data",header=None)

col_name = ['Class','Alcohol','Malic acid','Ash','Alcalinity of ash','Magnesium','Total phenols','Flavanoids',
        'Nonflavanoid phenols','Proanthocyanins','Color intensity','Hue','OD280/OD315 of diluted wines','Proline']


df.columns = col_name


X = df.drop(['Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X,y,train_size=0.4,test_size=0.6,random_state=10)
```

```
# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=3, covariance_type="full")
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 0:
        strings[i] = 1
        elif y_pred[i] == 1:
        strings[i] = 2
        else:
        strings[i] = 3

strings = strings.astype(np.int)



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score
```

```
print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("----------------------------------------------------")
print("----------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("----------------------------------------------------")
print("----------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# WINE DATASET
# GaussianHMM(Without Tuning)[30-70 split]


import pandas as pd
import numpy as np

# Dataset Preparation
```

```
df = pd.read_csv("wine.data",header=None)

col_name = ['Class','Alcohol','Malic acid','Ash','Alcalinity of
ash','Magnesium','Total phenols','Flavanoids',
        'Nonflavanoid phenols','Proanthocyanins','Color
intensity','Hue','OD280/OD315 of diluted wines','Proline']


df.columns = col_name



X = df.drop(['Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.3,test_size=0.7,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=3, covariance_type="full")
classifier.fit(X_train)
```

```
y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 0:
        strings[i] = 1
        elif y_pred[i] == 1:
        strings[i] = 2
        else:
        strings[i] = 3

strings = strings.astype(np.int)



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))
```

```
print("-----------------------------------------------")
print("-----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# WINE DATASET
# GaussianHMM(With Tuning)[70-30 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wine.data",header=None)

col_name = ['Class','Alcohol','Malic acid','Ash','Alcalinity of
ash','Magnesium','Total phenols','Flavanoids',
        'Nonflavanoid phenols','Proanthocyanins','Color
intensity','Hue','OD280/OD315 of diluted wines','Proline']


df.columns = col_name


X = df.drop(['Class'], axis=1)
```

```
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.7,test_size=0.3,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=3, covariance_type="full")
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
    if y_pred[i] == 0:
    strings[i] = 1
    elif y_pred[i] == 1:
    strings[i] = 2
    else:
```

```
        strings[i] = 3

strings = strings.astype(np.int)



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-------------------------------------------------")
print("-------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-------------------------------------------------")
print("-------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()
```

```
#################################################################################
###########################################################
#################################################################################
###########################################################
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# WINE DATASET
# GMMHMM(Without Tuning)[70-30 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wine.data",header=None)

col_name = ['Class','Alcohol','Malic acid','Ash','Alcalinity of
ash','Magnesium','Total phenols','Flavanoids',
        'Nonflavanoid phenols','Proanthocyanins','Color
intensity','Hue','OD280/OD315 of diluted wines','Proline']


df.columns = col_name


X = df.drop(['Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split
```

```
X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.7,test_size=0.3,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=3,
random_state=10,covariance_type='full',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 0:
        strings[i] = 3
        elif y_pred[i] == 1:
        strings[i] = 2
        else:
        strings[i] = 1

strings = strings.astype(np.int)
```

```
from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("------------------------------------------------")
print("------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()



# WINE DATASET
# GMMHMM(Without Tuning)[60-40 split]
```

```
import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wine.data",header=None)

col_name = ['Class','Alcohol','Malic acid','Ash','Alcalinity of
ash','Magnesium','Total phenols','Flavanoids',
        'Nonflavanoid phenols','Proanthocyanins','Color
intensity','Hue','OD280/OD315 of diluted wines','Proline']


df.columns = col_name


X = df.drop(['Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.6,test_size=0.4,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)
```

```
# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=3,
random_state=10,covariance_type='full',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 0:
        strings[i] = 3
        elif y_pred[i] == 1:
        strings[i] = 1
        else:
        strings[i] = 2

strings = strings.astype(np.int)


from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("---------------------------------------------------")
print("---------------------------------------------------")
```

```
print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-----------------------------------------------")
print("-----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()



# WINE DATASET
# GMMHMM(Without Tuning)[50-50 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wine.data",header=None)

col_name = ['Class','Alcohol','Malic acid','Ash','Alcalinity of
ash','Magnesium','Total phenols','Flavanoids',
```

```
        'Nonflavanoid phenols','Proanthocyanins','Color intensity','Hue','OD280/OD315 of diluted wines','Proline']


df.columns = col_name



X = df.drop(['Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X,y,train_size=0.5,test_size=0.5,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=3, random_state=10,covariance_type='full',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)
```

```
size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 0:
        strings[i] = 1
        elif y_pred[i] == 1:
        strings[i] = 3
        else:
        strings[i] = 2

strings = strings.astype(np.int)


from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("------------------------------------------------")
print("------------------------------------------------")

print("Accuracy:")
```

```
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()



# WINE DATASET
# GMMHMM(Without Tuning)[40-60 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wine.data",header=None)

col_name = ['Class','Alcohol','Malic acid','Ash','Alcalinity of
ash','Magnesium','Total phenols','Flavanoids',
        'Nonflavanoid phenols','Proanthocyanins','Color
intensity','Hue','OD280/OD315 of diluted wines','Proline']


df.columns = col_name


X = df.drop(['Class'], axis=1)
y = df['Class']
```

```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.4,test_size=0.6,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=3,
random_state=10,covariance_type='full',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
	if y_pred[i] == 0:
	strings[i] = 3
	elif y_pred[i] == 1:
	strings[i] = 2
	else:
	strings[i] = 1
```

```
strings = strings.astype(np.int)


from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("------------------------------------------------")
print("------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()
```

```
# WINE DATASET
# GMMHMM(Without Tuning)[30-70 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wine.data",header=None)

col_name = ['Class','Alcohol','Malic acid','Ash','Alcalinity of
ash','Magnesium','Total phenols','Flavanoids',
        'Nonflavanoid phenols','Proanthocyanins','Color
intensity','Hue','OD280/OD315 of diluted wines','Proline']


df.columns = col_name


X = df.drop(['Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.3,test_size=0.7,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
```

```
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=3,
random_state=10,covariance_type='diag',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
    if y_pred[i] == 0:
    strings[i] = 3
    elif y_pred[i] == 1:
    strings[i] = 1
    else:
    strings[i] = 2

strings = strings.astype(np.int)


from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))
```

```
print("-----------------------------------------------")
print("-----------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-----------------------------------------------")
print("-----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()


# IONOSPHERE DATASET
# GaussianHMM(Without Tuning)[70-30 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
```

```
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']

df.columns = col_name


X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.7,test_size=0.3,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2, covariance_type="full")
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)
```

```
for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("g")
        else:
        strings[i] = ("b")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("----------------------------------------------")
print("----------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("----------------------------------------------")
print("----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
```

```
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# GaussianHMM(Without Tuning)[60-40 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name


X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.6,test_size=0.4,random_state=10)


# Feature Scaling
```

```
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2, covariance_type="full")
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
    if y_pred[i] == 1:
    strings[i] = ("g")
    else:
    strings[i] = ("b")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))
```

```
print("-----------------------------------------------")
print("-----------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-----------------------------------------------")
print("-----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# GaussianHMM(Without Tuning)[50-50 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
```

```
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name



X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.5,test_size=0.5,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2, covariance_type="full")
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)
```

```
for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("g")
        else:
        strings[i] = ("b")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("--------------------------------------------------")
print("--------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("--------------------------------------------------")
print("--------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
```

```
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# GaussianHMM(Without Tuning)[40-60 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name



X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.4,test_size=0.6,random_state=10)


# Feature Scaling
```

```
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2,
covariance_type="full",algorithm='viterbi')
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("g")
        else:
        strings[i] = ("b")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
```

```
print(confusion_matrix(y_test, strings))

print("--------------------------------------------------")
print("--------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("--------------------------------------------------")
print("--------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# GaussianHMM(Without Tuning)[30-70 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)
```

```
col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
    ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name



X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.3,test_size=0.7,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2,
covariance_type="diag",algorithm='viterbi')
classifier.fit(X_train)

y_pred = classifier.predict(X_test)
```

```
size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
    if y_pred[i] == 1:
    strings[i] = ("g")
    else:
    strings[i] = ("b")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("------------------------------------------------")
print("------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))
```

```
import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# GaussianHMM(With Tuning)[70-30 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
    ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name


X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.7,test_size=0.3,random_state=10)
```

```
# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2,
covariance_type="full",n_iter=5,algorithm='viterbi',verbose=False)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("g")
        else:
        strings[i] = ("b")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score
```

```
print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("--------------------------------------------------")
print("--------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("--------------------------------------------------")
print("--------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# GaussianHMM(With Tuning)[60-40 split]


import pandas as pd
import numpy as np

# Dataset Preparation
```

```
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name



X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.6,test_size=0.4,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2,
covariance_type="full",n_iter=2,algorithm='viterbi',verbose=False)
classifier.fit(X_train)
```

```
y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("g")
        else:
        strings[i] = ("b")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("------------------------------------------------")
print("------------------------------------------------")
```

```
print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# GaussianHMM(With Tuning)[50-50 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name


X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split
```

```
X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.5,test_size=0.5,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2,
covariance_type="full",n_iter=5,algorithm='viterbi',verbose=False)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("b")
        else:
        strings[i] = ("g")

strings
```

```
from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("------------------------------------------------")
print("------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# GaussianHMM(With Tuning)[40-60 split]


import pandas as pd
```

```
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name



X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.4,test_size=0.6,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm
```

```
classifier = hmm.GaussianHMM(n_components=2,
covariance_type="full",n_iter=5,algorithm='viterbi',verbose=False)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("g")
        else:
        strings[i] = ("b")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-----------------------------------------------")
print("-----------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))
```

```
print("-----------------------------------------------")
print("-----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# GaussianHMM(With Tuning)[30-70 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name


X = df.drop(['1','2','Class'], axis=1)
y = df['Class']
```

```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.3,test_size=0.7,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2,
covariance_type="full",n_iter=5,algorithm='viterbi',verbose=False)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
    if y_pred[i] == 1:
    strings[i] = ("b")
    else:
    strings[i] = ("g")
```

```
strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("------------------------------------------------")
print("------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

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# IONOSPHERE DATASET
# GMMHMM(Without Tuning)[70-30 split]


import pandas as pd
```

```
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name



X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.7,test_size=0.3,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
```

```
classifier = hmmlearn.hmm.GMMHMM(n_components=2,
random_state=10,covariance_type='full',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("g")
        else:
        strings[i] = ("b")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("--------------------------------------------------")
print("--------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))
```

```
print("-----------------------------------------------")
print("-----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# GMMHMM(Without Tuning)[60-40 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
    ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name


X = df.drop(['1','2','Class'], axis=1)
y = df['Class']
```

```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.6,test_size=0.4,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2,
random_state=10,covariance_type='full',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
	if y_pred[i] == 1:
	strings[i] = ("g")
	else:
	strings[i] = ("b")
```

```
strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("--------------------------------------------------")
print("--------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("--------------------------------------------------")
print("--------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# GMMHMM(Without Tuning)[50-50 split]
```

```
import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name


X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.5,test_size=0.5,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
```

```
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2,
random_state=10,covariance_type='full',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
    if y_pred[i] == 1:
    strings[i] = ("g")
    else:
    strings[i] = ("b")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-----------------------------------------------")
print("-----------------------------------------------")


print("Performance Evaluation")
```

```
print(classification_report(y_test, strings))


print("-----------------------------------------------")
print("-----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# GMMHMM(Without Tuning)[40-60 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name
```

```
X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.4,test_size=0.6,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2,
random_state=10,covariance_type='full',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
    if y_pred[i] == 1:
    strings[i] = ("g")
    else:
```

```
    strings[i] = ("b")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("--------------------------------------------------")
print("--------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("--------------------------------------------------")
print("--------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()
```

```
# IONOSPHERE DATASET
# GMMHMM(Without Tuning)[30-70 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name



X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.3,test_size=0.7,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)
```

```
# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2,
random_state=10,covariance_type='full',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
    if y_pred[i] == 1:
    strings[i] = ("g")
    else:
    strings[i] = ("b")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-----------------------------------------------")
print("-----------------------------------------------")
```

```
print("Performance Evaluation")
print(classification_report(y_test, strings))


print("--------------------------------------------------")
print("--------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# GMMHMM(With Tuning)[70-30 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name
```

```
X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.7,test_size=0.3,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2,
random_state=10,covariance_type='full',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
    if y_pred[i] == 1:
```

```
        strings[i] = ("g")
        else:
        strings[i] = ("b")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("------------------------------------------------")
print("------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
```

```
plt.show()

# IONOSPHERE DATASET
# GMMHMM(With Tuning)[60-40 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name



X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.6,test_size=0.4,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
```

```
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2,
random_state=10,covariance_type='full',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("g")
        else:
        strings[i] = ("b")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
```

```
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("------------------------------------------------")
print("------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# GMMHMM(With Tuning)[50-50 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
       ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']
```

```
df.columns = col_name


X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.5,test_size=0.5,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2,
random_state=10,covariance_type='full',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)
```

```
for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("g")
        else:
        strings[i] = ("b")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-------------------------------------------------")
print("-------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-------------------------------------------------")
print("-------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
```

```
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# GMMHMM(With Tuning)[40-60 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name


X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.4,test_size=0.6,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler
```

```
sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2,
random_state=10,covariance_type='full',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("g")
        else:
        strings[i] = ("b")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))
```

```
print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("------------------------------------------------")
print("------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# GMMHMM(With Tuning)[30-70 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("ionosphere.data",header=None)

col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
```

```
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']

df.columns = col_name


X = df.drop(['1','2','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.3,test_size=0.7,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2,
random_state=10,covariance_type='full',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
```

```
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("g")
        else:
        strings[i] = ("b")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("------------------------------------------------")
print("------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))
```

```
import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

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# IONOSPHERE DATASET
# MultinomialHMM(Without Tuning)[70-30 split]
```

```
import pandas as pd
import numpy as np

# Dataset Preparation
col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name



X = df.drop(['1','2','Class'], axis=1)
y = df['Class']



X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.7,test_size=0.3,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)
```

```
# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.MultinomialHMM(n_components=4,
random_state=15,n_iter=10,algorithm='viterbi',params='ste')

import math
row = len(X_train)
col = len(X_train[0])
new = [1] * 33
for i in range(row):
        for j in range(col):
        X_train[i][j] = X_train[i][j]*10
        X_train[i][j] = math.floor(X_train[i][j])
        x = X_train[i].astype(np.int)
        new = np.vstack([new,x])

y = new
y = np.absolute(y)
X_train = y


import math
row = len(X_test)
col = len(X_test[0])
new
for i in range(row):
        for j in range(col):
        X_test[i][j] = X_test[i][j]*10
        X_test[i][j] = math.floor(X_test[i][j])
        x = X_test[i].astype(np.int)
        new = np.vstack([new,x])
```

```
y = new
y = np.absolute(y)
X_test = y


classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("g")
        else:
        strings[i] = ("b")

strings
strings = strings[0:106]


from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")
```

```
print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-------------------------------------------------")
print("-------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# MultinomialHMM(Without Tuning)[60-40 split]


import pandas as pd
import numpy as np

# Dataset Preparation
col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name
```

```
X = df.drop(['1','2','Class'], axis=1)
y = df['Class']


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.6,test_size=0.4,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.MultinomialHMM(n_components=4,
random_state=15,n_iter=10,algorithm='viterbi',params='ste')

import math
row = len(X_train)
col = len(X_train[0])
new = [1] * 33
for i in range(row):
	for j in range(col):
```

```
        X_train[i][j] = X_train[i][j]*10
        X_train[i][j] = math.floor(X_train[i][j])
        x = X_train[i].astype(np.int)
        new = np.vstack([new,x])

y = new
y = np.absolute(y)
X_train = y


import math
row = len(X_test)
col = len(X_test[0])
new
for i in range(row):
        for j in range(col):
        X_test[i][j] = X_test[i][j]*10
        X_test[i][j] = math.floor(X_test[i][j])
        x = X_test[i].astype(np.int)
        new = np.vstack([new,x])

y = new
y = np.absolute(y)
X_test = y


classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)
```

```
for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("g")
        else:
        strings[i] = ("b")

strings
strings = strings[0:141]


from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-----------------------------------------------")
print("-----------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-----------------------------------------------")
print("-----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
```

```
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# MultinomialHMM(Without Tuning)[50-50 split]


import pandas as pd
import numpy as np

# Dataset Preparation
col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name


X = df.drop(['1','2','Class'], axis=1)
y = df['Class']


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.5,test_size=0.5,random_state=10)
```

```
# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.MultinomialHMM(n_components=4,
random_state=15,n_iter=10,algorithm='viterbi',params='ste')

import math
row = len(X_train)
col = len(X_train[0])
new = [1] * 33
for i in range(row):
	for j in range(col):
	X_train[i][j] = X_train[i][j]*10
	X_train[i][j] = math.floor(X_train[i][j])
	x = X_train[i].astype(np.int)
	new = np.vstack([new,x])

y = new
y = np.absolute(y)
X_train = y


import math
row = len(X_test)
```

```
col = len(X_test[0])
new
for i in range(row):
        for j in range(col):
        X_test[i][j] = X_test[i][j]*10
        X_test[i][j] = math.floor(X_test[i][j])
        x = X_test[i].astype(np.int)
        new = np.vstack([new,x])

y = new
y = np.absolute(y)
X_test = y


classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("b")
        else:
        strings[i] = ("g")

strings
strings = strings[0:176]
```

```
from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("--------------------------------------------------")
print("--------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("--------------------------------------------------")
print("--------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# MultinomialHMM(Without Tuning)[40-60 split]


import pandas as pd
import numpy as np
```

```
# Dataset Preparation
col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name



X = df.drop(['1','2','Class'], axis=1)
y = df['Class']



X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.4,test_size=0.6,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
```

```
classifier = hmmlearn.hmm.MultinomialHMM(n_components=4,
random_state=15,n_iter=10,algorithm='viterbi',params='ste')

import math
row = len(X_train)
col = len(X_train[0])
new = [1] * 33
for i in range(row):
        for j in range(col):
        X_train[i][j] = X_train[i][j]*10
        X_train[i][j] = math.floor(X_train[i][j])
        x = X_train[i].astype(np.int)
        new = np.vstack([new,x])

y = new
y = np.absolute(y)
X_train = y


import math
row = len(X_test)
col = len(X_test[0])
new
for i in range(row):
        for j in range(col):
        X_test[i][j] = X_test[i][j]*10
        X_test[i][j] = math.floor(X_test[i][j])
        x = X_test[i].astype(np.int)
        new = np.vstack([new,x])

y = new
y = np.absolute(y)
```

```
X_test = y


classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("b")
        else:
        strings[i] = ("g")

strings
strings = strings[0:211]


from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-----------------------------------------------")
print("-----------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))
```

```
print("-------------------------------------------------")
print("-------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# IONOSPHERE DATASET
# MultinomialHMM(Without Tuning)[30-70 split]


import pandas as pd
import numpy as np

# Dataset Preparation
col_name = ['1','2','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
       ,'20','21','22','23','24','25','26','27','28','29','30','31','32','33','34','Class']


df.columns = col_name


X = df.drop(['1','2','Class'], axis=1)
y = df['Class']
```

```
X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.3,test_size=0.7,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.MultinomialHMM(n_components=4,
random_state=15,n_iter=10,algorithm='viterbi',params='ste')

import math
row = len(X_train)
col = len(X_train[0])
new = [1] * 33
for i in range(row):
    for j in range(col):
    X_train[i][j] = X_train[i][j]*10
    X_train[i][j] = math.floor(X_train[i][j])
    x = X_train[i].astype(np.int)
```

```
        new = np.vstack([new,x])

y = new
y = np.absolute(y)
X_train = y


import math
row = len(X_test)
col = len(X_test[0])
new
for i in range(row):
        for j in range(col):
        X_test[i][j] = X_test[i][j]*10
        X_test[i][j] = math.floor(X_test[i][j])
        x = X_test[i].astype(np.int)
        new = np.vstack([new,x])

y = new
y = np.absolute(y)
X_test = y


classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
```

```
        strings[i] = ("b")
        else:
        strings[i] = ("g")

strings
strings = strings[0:246]


from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-------------------------------------------------")
print("-------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-------------------------------------------------")
print("-------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
```

```
plt.show()




# BREAST CANCER DATASET
# GaussianHMM(Without Tuning)[70-30 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name



X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.7,test_size=0.3,random_state=10)


# Feature Scaling
```

```
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2, covariance_type="full")
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
    if y_pred[i] == 1:
    strings[i] = ("M")
    else:
    strings[i] = ("B")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))
```

```
print("-------------------------------------------------")
print("-------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-------------------------------------------------")
print("-------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GaussianHMM(Without Tuning)[60-40 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)
```

```
col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name



X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.6,test_size=0.4,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2, covariance_type="full")
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
```

```
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("M")
        else:
        strings[i] = ("B")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-----------------------------------------------")
print("-----------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-----------------------------------------------")
print("-----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))
```

```
import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GaussianHMM(Without Tuning)[50-50 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.5,test_size=0.5,random_state=10)
```

```
# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2,
covariance_type="full",n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
	if y_pred[i] == 1:
	strings[i] = ("M")
	else:
	strings[i] = ("B")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score
```

```
print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-------------------------------------------------")
print("-------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-------------------------------------------------")
print("-------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GaussianHMM(Without Tuning)[40-60 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)
```

```
col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
    ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name



X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.4,test_size=0.6,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2,
covariance_type="full",n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)
```

```
size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
	if y_pred[i] == 1:
	strings[i] = ("M")
	else:
	strings[i] = ("B")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("--------------------------------------------------")
print("--------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("--------------------------------------------------")
print("--------------------------------------------------")

print("Accuracy:")
```

```
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GaussianHMM(Without Tuning)[30-70 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.3,test_size=0.7,random_state=10)
```

```
# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2,
covariance_type="full",n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("M")
        else:
        strings[i] = ("B")

strings
```

```
from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("------------------------------------------------")
print("------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GaussianHMM(With Tuning)[70-30 split]


import pandas as pd
import numpy as np
```

```
# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
    ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.7,test_size=0.3,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2,
covariance_type="full",n_iter=10,algorithm='viterbi',verbose=False)
```

```
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("M")
        else:
        strings[i] = ("B")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("------------------------------------------------")
```

```
print("----------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GaussianHMM(With Tuning)[60-40 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split
```

```
X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.6,test_size=0.4,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2,
covariance_type="full",n_iter=10,algorithm='viterbi',verbose=False)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
    if y_pred[i] == 1:
    strings[i] = ("M")
    else:
    strings[i] = ("B")

strings
```

```
from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("--------------------------------------------------")
print("--------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("--------------------------------------------------")
print("--------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GaussianHMM(With Tuning)[50-50 split]
```

```
import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.5,test_size=0.5,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm
```

```
classifier = hmm.GaussianHMM(n_components=2,
covariance_type="full",n_iter=10,algorithm='viterbi',verbose=False)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("M")
        else:
        strings[i] = ("B")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))
```

```
print("------------------------------------------------")
print("------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GaussianHMM(With Tuning)[40-60 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']
```

```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.4,test_size=0.6,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2,
covariance_type="full",n_iter=10,algorithm='viterbi',verbose=False)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
    if y_pred[i] == 1:
    strings[i] = ("M")
    else:
    strings[i] = ("B")
```

```
strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("--------------------------------------------------")
print("--------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("--------------------------------------------------")
print("--------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GaussianHMM(With Tuning)[30-70 split]
```

```
import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.3,test_size=0.7,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
```

```
from hmmlearn import hmm

classifier = hmm.GaussianHMM(n_components=2,
covariance_type="full",n_iter=10,algorithm='viterbi',verbose=False)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("M")
        else:
        strings[i] = ("B")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-------------------------------------------------")
print("-------------------------------------------------")


print("Performance Evaluation")
```

```
print(classification_report(y_test, strings))


print("------------------------------------------------")
print("------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

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# BREAST CANCER DATASET
# GMMHMM(Without Tuning)[70-30 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)
```

```
col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.7,test_size=0.3,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2, random_state=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
```

```
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("M")
        else:
        strings[i] = ("B")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-----------------------------------------------")
print("-----------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-----------------------------------------------")
print("-----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))
```

```
import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GMMHMM(Without Tuning)[60-40 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.6,test_size=0.4,random_state=10)
```

```
# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2, random_state=2)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
    if y_pred[i] == 1:
    strings[i] = ("M")
    else:
    strings[i] = ("B")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
```

```
print(confusion_matrix(y_test, strings))

print("--------------------------------------------------")
print("--------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("--------------------------------------------------")
print("--------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GMMHMM(Without Tuning)[50-50 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)
```

```
col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name



X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.5,test_size=0.5,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2, random_state=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
```

```
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("M")
        else:
        strings[i] = ("B")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("------------------------------------------------")
print("------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))
```

```
import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GMMHMM(Without Tuning)[40-60 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.4,test_size=0.6,random_state=10)
```

```
# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2, random_state=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("M")
        else:
        strings[i] = ("B")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
```

```
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("------------------------------------------------")
print("------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GMMHMM(Without Tuning)[30-70 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)
```

```
col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.3,test_size=0.7,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2, random_state=2)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
```

```
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("M")
        else:
        strings[i] = ("B")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-----------------------------------------------")
print("-----------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-----------------------------------------------")
print("-----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))
```

```
import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GMMHMM(With Tuning)[70-30 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
    ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.7,test_size=0.3,random_state=10)
```

```
# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2,
random_state=10,covariance_type='diag',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("M")
        else:
        strings[i] = ("B")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score
```

```
print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("--------------------------------------------------")
print("--------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("--------------------------------------------------")
print("--------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GMMHMM(With Tuning)[60-40 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)
```

```
col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.6,test_size=0.4,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2,
random_state=2,covariance_type='diag',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)
```

```
size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
	if y_pred[i] == 1:
	strings[i] = ("M")
	else:
	strings[i] = ("B")

strings




from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-------------------------------------------------")
print("-------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-------------------------------------------------")
print("-------------------------------------------------")

print("Accuracy:")
```

```
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GMMHMM(With Tuning)[50-50 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.5,test_size=0.5,random_state=10)
```

```
# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2,
random_state=10,covariance_type='diag',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("M")
        else:
        strings[i] = ("B")

strings
```

```python
from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("----------------------------------------------")
print("----------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("----------------------------------------------")
print("----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GMMHMM(With Tuning)[40-60 split]


import pandas as pd
import numpy as np
```

```
# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.4,test_size=0.6,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=2,
random_state=10,covariance_type='diag',algorithm='viterbi',n_iter=10)
```

```
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
    if y_pred[i] == 1:
    strings[i] = ("M")
    else:
    strings[i] = ("B")

strings



from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("------------------------------------------------")
```

```
print("-----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# GMMHMM(With Tuning)[30-70 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name



X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split
```

```
X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.3,test_size=0.7,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.GMMHMM(n_components=5,
random_state=20,covariance_type='diag',algorithm='viterbi',n_iter=10)
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("M")
        else:
        strings[i] = ("B")

strings
```

```
from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("---------------------------------------------------------")
print("---------------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("---------------------------------------------------------")
print("---------------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

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# BREAST CANCER DATASET
# MultinomialHMM(With Tuning)[70-30 split]


import pandas as pd
import numpy as np
```

```
# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name



X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.7,test_size=0.3,random_state=10)



# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.MultinomialHMM(n_components=4,
random_state=15,n_iter=10,algorithm='viterbi',params='ste')
```

```
import math
row = len(X_train)
col = len(X_train[0])
new
for i in range(row):
    for j in range(col):
    X_train[i][j] = X_train[i][j]*10
    X_train[i][j] = math.floor(X_train[i][j])
    x = X_train[i].astype(np.int)
    new = np.vstack([new,x])

y = new
y = np.absolute(y)
X_train = y


import math
row = len(X_test)
col = len(X_test[0])
new
for i in range(row):
    for j in range(col):
    X_test[i][j] = X_test[i][j]*10
    X_test[i][j] = math.floor(X_test[i][j])
    x = X_test[i].astype(np.int)
    new = np.vstack([new,x])

y = new
y = np.absolute(y)
X_test = y
```

```
classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("M")
        else:
        strings[i] = ("B")

strings
strings = strings[0:171]


from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-----------------------------------------------")
print("-----------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-----------------------------------------------")
```

```
print("-----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# MultinomialHMM(With Tuning)[60-40 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split
```

```
X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.6,test_size=0.4,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.MultinomialHMM(n_components=4,
random_state=15,n_iter=10,algorithm='viterbi',params='ste')

import math
row = len(X_train)
col = len(X_train[0])
new
for i in range(row):
	for j in range(col):
	X_train[i][j] = X_train[i][j]*10
	X_train[i][j] = math.floor(X_train[i][j])
	x = X_train[i].astype(np.int)
	new = np.vstack([new,x])

y = new
y = np.absolute(y)
X_train = y
```

```
import math
row = len(X_test)
col = len(X_test[0])
new
for i in range(row):
    for j in range(col):
    X_test[i][j] = X_test[i][j]*10
    X_test[i][j] = math.floor(X_test[i][j])
    x = X_test[i].astype(np.int)
    new = np.vstack([new,x])

y = new
y = np.absolute(y)
X_test = y


classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
    if y_pred[i] == 1:
    strings[i] = ("M")
    else:
    strings[i] = ("B")

strings
```

```
strings = strings[0:228]


from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("--------------------------------------------------")
print("--------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("--------------------------------------------------")
print("--------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# MultinomialHMM(With Tuning)[50-50 split]
```

```
import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.5,test_size=0.5,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
```

```
import hmmlearn
classifier = hmmlearn.hmm.MultinomialHMM(n_components=4,
random_state=15,n_iter=10,algorithm='viterbi',params='ste')

import math
row = len(X_train)
col = len(X_train[0])
new
for i in range(row):
	for j in range(col):
	X_train[i][j] = X_train[i][j]*10
	X_train[i][j] = math.floor(X_train[i][j])
	x = X_train[i].astype(np.int)
	new = np.vstack([new,x])

y = new
y = np.absolute(y)
X_train = y


import math
row = len(X_test)
col = len(X_test[0])
new
for i in range(row):
	for j in range(col):
	X_test[i][j] = X_test[i][j]*10
	X_test[i][j] = math.floor(X_test[i][j])
	x = X_test[i].astype(np.int)
	new = np.vstack([new,x])

y = new
```

```
y = np.absolute(y)
X_test = y


classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("M")
        else:
        strings[i] = ("B")

strings
strings = strings[0:285]


from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-----------------------------------------------")
print("-----------------------------------------------")


print("Performance Evaluation")
```

```
print(classification_report(y_test, strings))


print("-----------------------------------------------")
print("-----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# BREAST CANCER DATASET
# MultinomialHMM(With Tuning)[40-60 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name
```

```
X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.4,test_size=0.6,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.MultinomialHMM(n_components=4,
random_state=15,n_iter=10,algorithm='viterbi',params='ste')

import math
row = len(X_train)
col = len(X_train[0])
new
for i in range(row):
	for j in range(col):
	X_train[i][j] = X_train[i][j]*10
	X_train[i][j] = math.floor(X_train[i][j])
	x = X_train[i].astype(np.int)
	new = np.vstack([new,x])
```

```
y = new
y = np.absolute(y)
X_train = y


import math
row = len(X_test)
col = len(X_test[0])
new
for i in range(row):
        for j in range(col):
        X_test[i][j] = X_test[i][j]*10
        X_test[i][j] = math.floor(X_test[i][j])
        x = X_test[i].astype(np.int)
        new = np.vstack([new,x])

y = new
y = np.absolute(y)
X_test = y


classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("M")
```

```
        else:
        strings[i] = ("B")

strings
strings = strings[0:342]


from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("------------------------------------------------")
print("------------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("------------------------------------------------")
print("------------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()
```

```
# BREAST CANCER DATASET
# MultinomialHMM(With Tuning)[30-70 split]


import pandas as pd
import numpy as np

# Dataset Preparation
df = pd.read_csv("wdbc.data",header=None)

col_name =
['1','Class','3','4','5','6','7','8','9','10','11','12','13','14','15','16','17','18','19'
        ,'20','21','22','23','24','25','26','27','28','29','30','31','32']

df.columns = col_name


X = df.drop(['1','Class'], axis=1)
y = df['Class']

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test =
train_test_split(X,y,train_size=0.3,test_size=0.7,random_state=10)


# Feature Scaling
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()
X_train = sc.fit_transform(X_train)
```

```
X_test = sc.transform(X_test)

# Classification
# from hmmlearn import hmm
import hmmlearn
classifier = hmmlearn.hmm.MultinomialHMM(n_components=4,
random_state=15,n_iter=10,algorithm='viterbi',params='ste')

import math
row = len(X_train)
col = len(X_train[0])
new
for i in range(row):
        for j in range(col):
        X_train[i][j] = X_train[i][j]*10
        X_train[i][j] = math.floor(X_train[i][j])
        x = X_train[i].astype(np.int)
        new = np.vstack([new,x])

y = new
y = np.absolute(y)
X_train = y


import math
row = len(X_test)
col = len(X_test[0])
new
for i in range(row):
        for j in range(col):
        X_test[i][j] = X_test[i][j]*10
        X_test[i][j] = math.floor(X_test[i][j])
```

```
        x = X_test[i].astype(np.int)
        new = np.vstack([new,x])

y = new
y = np.absolute(y)
X_test = y


classifier.fit(X_train)

y_pred = classifier.predict(X_test)

size = len(y_pred)
strings = np.empty(size, np.unicode_)

for i in range (size):
        if y_pred[i] == 1:
        strings[i] = ("M")
        else:
        strings[i] = ("B")

strings
strings = strings[0:399]


from sklearn.metrics import classification_report, confusion_matrix,
accuracy_score

print("Confusion Matrix:")
print(confusion_matrix(y_test, strings))

print("-------------------------------------------------")
```

```
print("-----------------------------------------------")


print("Performance Evaluation")
print(classification_report(y_test, strings))


print("-----------------------------------------------")
print("-----------------------------------------------")

print("Accuracy:")
print(accuracy_score(y_test, strings))

import matplotlib.pyplot as plt
import seaborn as sns
cm = confusion_matrix(y_test, strings)
sns.heatmap(cm, annot=True, fmt="d",cmap='Blues')
plt.show()

# CIFAR 10 DATASET

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf

# dataset preparation

from tensorflow.keras import datasets,layers,models

(train_images,train_labels) , (test_images,test_labels) =
datasets.cifar10.load_data()
```

```
# Normalize pixel values to be within 0 , 1
train_images , test_images = train_images/255.0 , test_images/255.0

input_shape = train_images[0].shape

model = models.Sequential()
model.add(layers.Conv2D(32,(3,3),activation='relu',input_shape=input_shape))
model.add(layers.MaxPool2D(2,2))
model.add(layers.Conv2D(64,(3,3),activation='relu'))
model.add(layers.MaxPool2D(2,2))
model.add(layers.Conv2D(64,(3,3),activation='relu'))

model.add(layers.Flatten())
model.add(layers.Dense(64,activation='relu'))
model.add(layers.Dense(10))


model.summary()

model.compile(optimizer='adam',loss=tf.keras.losses.SparseCategoricalCrossentro
py(from_logits=True),metrics=['accuracy'])

history =
model.fit(train_images,train_labels,epochs=20,validation_data=(test_images,test_l
abels))

plt.plot(history.history['accuracy'],label='accuracy')
plt.plot(history.history['val_accuracy'],label='val_accuracy')
plt.xlabel('epoch')
plt.ylabel('accuracy')
plt.ylim([0.5,1])
```

```
plt.legend(loc='lower right')

plt.show()

test_loss , test_acc = model.evaluate(test_images,test_labels,verbose=2)

# MNIST DATASET

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf

# dataset preparation

from tensorflow.keras import datasets,layers,models

(train_images,train_labels) , (test_images,test_labels) = datasets.mnist.load_data()

# Normalize pixel values to be within 0 , 1
train_images , test_images = train_images/255.0 , test_images/255.0

train_images = np.reshape(train_images, train_images.shape + (1,))
test_images = np.reshape(test_images, test_images.shape + (1,))

train_images[0].shape

model = models.Sequential()
model.add(layers.Conv2D(32,(3,3),activation='relu',input_shape=(28,28,1)))
model.add(layers.MaxPool2D(2,2))
model.add(layers.Conv2D(64,(3,3),activation='relu'))
model.add(layers.MaxPool2D(2,2))
```

```
model.add(layers.Conv2D(64,(3,3),activation='relu'))

model.add(layers.Flatten())
model.add(layers.Dense(64,activation='relu'))
model.add(layers.Dense(10))


model.summary()

model.compile(optimizer='adam',loss=tf.keras.losses.SparseCategoricalCrossentro
py(from_logits=True),metrics=['accuracy'])

history =
model.fit(train_images,train_labels,epochs=20,validation_data=(test_images,test_l
abels))

plt.plot(history.history['accuracy'],label='accuracy')
plt.plot(history.history['val_accuracy'],label='val_accuracy')
plt.xlabel('epoch')
plt.ylabel('accuracy')
plt.ylim([0.5,1])
plt.legend(loc='lower right')

plt.show()

test_loss , test_acc = model.evaluate(test_images,test_labels,verbose=2)

# SAVEE DATASET

!unzip "/content/drive/MyDrive/SaveeDataset.zip"

import librosa
```

```
import numpy as np

input_length = 16000*5

batch_size = 32

n_mels = 320

def preprocess_audio_mel_T(audio, sample_rate=16000, window_size=20,
#log_specgram
                 step_size=10, eps=1e-10):

        mel_spec = librosa.feature.melspectrogram(y=audio, sr=sample_rate,
n_mels= n_mels)
        mel_db = (librosa.power_to_db(mel_spec, ref=np.max) + 40)/40

        return mel_db.T


def load_audio_file(file_path, input_length=input_length):
  data = librosa.core.load(file_path, sr=16000)[0] #, sr=16000
  if len(data)>input_length:
        max_offset = len(data)-input_length

        offset = np.random.randint(max_offset)

        data = data[offset:(input_length+offset)]

  else:
        if input_length > len(data):
        max_offset = input_length - len(data)
```

```
        offset = np.random.randint(max_offset)
        else:
        offset = 0
        data = np.pad(data, (offset, input_length - len(data) - offset), "constant")

  data = preprocess_audio_mel_T(data)
  return data

# Preprocessing the dataset
import os
from scipy.io import wavfile
import librosa
import matplotlib.pyplot as plt
import numpy as np

rootDirectory = "/content/AudioData/"
personNames = ["DC","JE","JK","KL"]

classes = ["a" , "d" , "f", "h", "n", "sa" , "su" ]

X = list()
y = list()

for person in personNames:
  directory = os.path.join(rootDirectory,person)
  for filename in os.listdir(directory):
        filePath = os.path.join(directory, filename)
        data = load_audio_file(file_path=filePath)
        data = np.reshape(data, data.shape + (1,))
        if(filename[0:1] in classes):
        X.append(data)
        y.append(classes.index(filename[0:1]))
```

```
        elif(filename[0:2] in classes):
        X.append(data)
        y.append(classes.index(filename[0:2]))

X = np.asarray(X, dtype=np.float32)
y = np.asarray(y, dtype=np.float32)

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf

# dataset preparation

from tensorflow.keras import datasets,layers,models
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, train_size= 0.7
,random_state=10)

model = models.Sequential()
model.add(layers.Conv2D(32,(3,3),activation='relu',input_shape=(157,320,1)))
model.add(layers.MaxPool2D(2,2))
model.add(layers.Conv2D(64,(3,3),activation='relu'))
model.add(layers.MaxPool2D(2,2))
model.add(layers.Conv2D(64,(3,3),activation='relu'))

model.add(layers.Flatten())
model.add(layers.Dense(64,activation='relu'))
model.add(layers.Dense(10))


model.summary()
```

```
model.compile(optimizer='adam',loss=tf.keras.losses.SparseCategoricalCrossentro
py(from_logits=True),metrics=['accuracy'])

history = model.fit(X_train,y_train,epochs=30,validation_data=(X_test,y_test))

plt.plot(history.history['accuracy'],label='accuracy')
plt.plot(history.history['val_accuracy'],label='val_accuracy')
plt.xlabel('epoch')
plt.ylabel('accuracy')
plt.ylim([0.5,1])
plt.legend(loc='lower right')

plt.show()

test_loss , test_acc = model.evaluate(X_test,y_test,verbose=2)

# EmoDB DATASET

!unzip "/content/drive/MyDrive/EmoDB.zip"

import librosa
import numpy as np

input_length = 16000*5

batch_size = 32

n_mels = 320

def preprocess_audio_mel_T(audio, sample_rate=16000, window_size=20,
#log_specgram
```

```
            step_size=10, eps=1e-10):

    mel_spec = librosa.feature.melspectrogram(y=audio, sr=sample_rate,
n_mels= n_mels)
    mel_db = (librosa.power_to_db(mel_spec, ref=np.max) + 40)/40

    return mel_db.T


def load_audio_file(file_path, input_length=input_length):
  data = librosa.core.load(file_path, sr=16000)[0] #, sr=16000
  if len(data)>input_length:
    max_offset = len(data)-input_length

    offset = np.random.randint(max_offset)

    data = data[offset:(input_length+offset)]

  else:
    if input_length > len(data):
    max_offset = input_length - len(data)

    offset = np.random.randint(max_offset)
    else:
    offset = 0
    data = np.pad(data, (offset, input_length - len(data) - offset), "constant")

  data = preprocess_audio_mel_T(data)
  return data

# Preprocessing the dataset
import os
```

```
from scipy.io import wavfile
import librosa
import matplotlib.pyplot as plt
import numpy as np

directory = "/content/wav/"

classes = ["W" ,"L" ,"E" ,"A" , "F" ,"T" ,"N" ]

X = list()
y = list()

for filename in os.listdir(directory):
  filePath = os.path.join(directory, filename)
  data = load_audio_file(file_path=filePath)
  data = np.reshape(data, data.shape + (1,))
  if(filename[5:6] in classes):
        X.append(data)
        y.append(classes.index(filename[5:6]))

X = np.asarray(X, dtype=np.float32)
y = np.asarray(y, dtype=np.float32)

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf

# dataset preparation

from tensorflow.keras import datasets,layers,models
from sklearn.model_selection import train_test_split
```

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, train_size= 0.7
,random_state=10)

model = models.Sequential()
model.add(layers.Conv2D(32,(3,3),activation='relu',input_shape=(157,320,1)))
model.add(layers.MaxPool2D(2,2))
model.add(layers.Conv2D(64,(3,3),activation='relu'))
model.add(layers.MaxPool2D(2,2))
model.add(layers.Conv2D(64,(3,3),activation='relu'))

model.add(layers.Flatten())
model.add(layers.Dense(64,activation='relu'))
model.add(layers.Dense(10))


model.summary()

model.compile(optimizer='adam',loss=tf.keras.losses.SparseCategoricalCrossentro
py(from_logits=True),metrics=['accuracy'])

history = model.fit(X_train,y_train,epochs=20,validation_data=(X_test,y_test))

plt.plot(history.history['accuracy'],label='accuracy')
plt.plot(history.history['val_accuracy'],label='val_accuracy')
plt.xlabel('epoch')
plt.ylabel('accuracy')
plt.ylim([0,1])
plt.legend(loc='lower right')

plt.show()

test_loss , test_acc = model.evaluate(X_test,y_test,verbose=2)
```

```
#@title
from google.colab import drive
drive.mount('/content/drive')

#@title
import tensorflow as tf
from tensorflow import keras
import matplotlib.pyplot as plt
%matplotlib inline
import numpy as np
import skimage.transform
from __future__ import print_function

!pip install keras_applications

import numpy as np
import warnings

from keras.models import Model
from keras.layers import Flatten
from keras.layers import Dense
from keras.layers import Input
from keras.layers import Conv2D
from keras.layers import MaxPooling2D
from keras.layers import GlobalMaxPooling2D
from keras.layers import GlobalAveragePooling2D
from keras.preprocessing import image
from keras.utils import layer_utils
from keras.utils.data_utils import get_file
from keras import backend as K
from keras.applications.imagenet_utils import decode_predictions
from keras.applications.imagenet_utils import preprocess_input
```

```
from keras_applications.imagenet_utils import _obtain_input_shape
from keras.utils.layer_utils import get_source_inputs



#@title
def load_preprocess_training_batch(X_train):

    new = []

    for item in X_train:
    tmpFeature = skimage.transform.resize(item, (224, 224), mode='constant')
    new.append(tmpFeature)

    return new

#@title
def preprocess_data(X_train):

    for item in X_train:
    item = np.expand_dims(item, axis=0)
    item = preprocess_input(item)

    return X_train

#@title
WEIGHTS_PATH = 'https://github.com/fchollet/deep-learning-models/releases/download/v0.1/vgg16_weights_tf_dim_ordering_tf_kernels.h5'
WEIGHTS_PATH_NO_TOP = 'https://github.com/fchollet/deep-learning-models/releases/download/v0.1/vgg16_weights_tf_dim_ordering_tf_kernels_notop.h5'
```

```
def VGG16(include_top=True, weights='imagenet',
        input_tensor=None, input_shape=None,
        pooling=None,
        classes=1000):
        """Instantiates the VGG16 architecture.

        Optionally loads weights pre-trained
        on ImageNet. Note that when using TensorFlow,
        for best performance you should set
        `image_data_format="channels_last"` in your Keras config
        at ~/.keras/keras.json.

        The model and the weights are compatible with both
        TensorFlow and Theano. The data format
        convention used by the model is the one
        specified in your Keras config file.

        # Arguments
        include_top: whether to include the 3 fully-connected
        layers at the top of the network.
        weights: one of `None` (random initialization)
        or "imagenet" (pre-training on ImageNet).
        input_tensor: optional Keras tensor (i.e. output of `layers.Input()`)
        to use as image input for the model.
        input_shape: optional shape tuple, only to be specified
        if `include_top` is False (otherwise the input shape
        has to be `(224, 224, 3)` (with `channels_last` data format)
        or `(3, 224, 244)` (with `channels_first` data format).
        It should have exactly 3 inputs channels,
        and width and height should be no smaller than 48.
        E.g. `(200, 200, 3)` would be one valid value.
```

```
pooling: Optional pooling mode for feature extraction
when `include_top` is `False`.
- `None` means that the output of the model will be
        the 4D tensor output of the
        last convolutional layer.
- `avg` means that global average pooling
        will be applied to the output of the
        last convolutional layer, and thus
        the output of the model will be a 2D tensor.
- `max` means that global max pooling will
        be applied.
classes: optional number of classes to classify images
into, only to be specified if `include_top` is True, and
if no `weights` argument is specified.

# Returns
A Keras model instance.

# Raises
ValueError: in case of invalid argument for `weights`,
or invalid input shape.
"""
if weights not in {'imagenet', None}:
raise ValueError('The `weights` argument should be either '
                '`None` (random initialization) or `imagenet` '
                '(pre-training on ImageNet).')

if weights == 'imagenet' and include_top and classes != 1000:
raise ValueError('If using `weights` as imagenet with `include_top`'
                ' as true, `classes` should be 1000')
# Determine proper input shape
input_shape = _obtain_input_shape(input_shape,
```

```
                                  default_size=224,
                                  min_size=48,
                                  data_format=K.image_data_format(),
                                  require_flatten=include_top)

    if input_tensor is None:
    img_input = Input(shape=input_shape)
    else:
    if not K.is_keras_tensor(input_tensor):
    img_input = Input(tensor=input_tensor, shape=input_shape)
    else:
    img_input = input_tensor
    # Block 1
    x = Conv2D(64, (3, 3), activation='relu', padding='same',
name='block1_conv1')(img_input)
    x = Conv2D(64, (3, 3), activation='relu', padding='same',
name='block1_conv2')(x)
    x = MaxPooling2D((2, 2), strides=(2, 2), name='block1_pool')(x)

    # Block 2
    x = Conv2D(128, (3, 3), activation='relu', padding='same',
name='block2_conv1')(x)
    x = Conv2D(128, (3, 3), activation='relu', padding='same',
name='block2_conv2')(x)
    x = MaxPooling2D((2, 2), strides=(2, 2), name='block2_pool')(x)

    # Block 3
    x = Conv2D(256, (3, 3), activation='relu', padding='same',
name='block3_conv1')(x)
    x = Conv2D(256, (3, 3), activation='relu', padding='same',
name='block3_conv2')(x)
```

```
x = Conv2D(256, (3, 3), activation='relu', padding='same',
name='block3_conv3')(x)
x = MaxPooling2D((2, 2), strides=(2, 2), name='block3_pool')(x)

# Block 4
x = Conv2D(512, (3, 3), activation='relu', padding='same',
name='block4_conv1')(x)
x = Conv2D(512, (3, 3), activation='relu', padding='same',
name='block4_conv2')(x)
x = Conv2D(512, (3, 3), activation='relu', padding='same',
name='block4_conv3')(x)
x = MaxPooling2D((2, 2), strides=(2, 2), name='block4_pool')(x)

# Block 5
x = Conv2D(512, (3, 3), activation='relu', padding='same',
name='block5_conv1')(x)
x = Conv2D(512, (3, 3), activation='relu', padding='same',
name='block5_conv2')(x)
x = Conv2D(512, (3, 3), activation='relu', padding='same',
name='block5_conv3')(x)
x = MaxPooling2D((2, 2), strides=(2, 2), name='block5_pool')(x)

if include_top:
# Classification block
x = Flatten(name='flatten')(x)
x = Dense(4096, activation='relu', name='fc1')(x)
x = Dense(4096, activation='relu', name='fc2')(x)
x = Dense(classes, activation='softmax', name='predictions')(x)
else:
if pooling == 'avg':
x = GlobalAveragePooling2D()(x)
elif pooling == 'max':
```

```
        x = GlobalMaxPooling2D()(x)

        # Ensure that the model takes into account
        # any potential predecessors of `input_tensor`.
        if input_tensor is not None:
        inputs = get_source_inputs(input_tensor)
        else:
        inputs = img_input
        # Create model.
        model = Model(inputs, x, name='vgg16')

        # load weights
        if weights == 'imagenet':
        if include_top:
        weights_path = get_file('vgg16_weights_tf_dim_ordering_tf_kernels.h5',
                                WEIGHTS_PATH,
                                cache_subdir='models')
        else:
        weights_path =
get_file('vgg16_weights_tf_dim_ordering_tf_kernels_notop.h5',
                                WEIGHTS_PATH_NO_TOP,
                                cache_subdir='models')
        model.load_weights(weights_path)
        if K.backend() == 'theano':
        layer_utils.convert_all_kernels_in_model(model)

        if K.image_data_format() == 'channels_first':
        if include_top:
            maxpool = model.get_layer(name='block5_pool')
            shape = maxpool.output_shape[1:]
            dense = model.get_layer(name='fc1')
```

```
            layer_utils.convert_dense_weights_data_format(dense, shape,
'channels_first')

        if K.backend() == 'tensorflow':
            warnings.warn('You are using the TensorFlow backend, yet you '
                    'are using the Theano '
                    'image data format convention '
                    '(`image_data_format="channels_first"`). '
                    'For best performance, set '
                    '`image_data_format="channels_last"` in '
                    'your Keras config '
                    'at ~/.keras/keras.json.')
        return model

#@title
import tensorflow as tf
from tensorflow import keras
import matplotlib.pyplot as plt
%matplotlib inline
import numpy as np
import skimage.transform

# CIFAR-10 Dataset

#@title

(X_train, y_train) , (X_test, y_test) = keras.datasets.cifar10.load_data()

X_train = X_train[0:2000]
y_train = y_train[0:2000]
X_test = X_test[0:2000]
y_test = y_test[0:2000]
```

```
#@title
X_train_resized = load_preprocess_training_batch(X_train)
X_test_resized = load_preprocess_training_batch(X_test)

#@title
X_train_resized = np.array(X_train_resized)
X_test_resized = np.array(X_test_resized)

#@title
X_train_resized = X_train_resized / 255
X_test_resized = X_test_resized / 255

#@title
X_train_resized = preprocess_data(X_train_resized)
X_test_resized = preprocess_data(X_test_resized)

#@title
model = VGG16(include_top=True, weights='imagenet')

model.compile(optimizer='SGD',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(X_train_resized, y_train, epochs=5)

# img_path = 'a.jpg'
# img = image.load_img(img_path, target_size=(224, 224))
# x = image.img_to_array(img)
# x = np.expand_dims(x, axis=0)
# x = preprocess_input(x)
# print('Input image shape:', x.shape)
```

```
# preds = model.predict(x)
# print('Predicted:', decode_predictions(preds))

#@title
model.evaluate(X_test_resized, y_test)

# MNIST Dataset

#@title
(X_train, y_train) , (X_test, y_test) = keras.datasets.mnist.load_data()

X_train = X_train[0:2000]
y_train = y_train[0:2000]
X_test = X_test[0:2000]
y_test = y_test[0:2000]

#@title
X_train_resized = load_preprocess_training_batch(X_train)
X_test_resized = load_preprocess_training_batch(X_test)

X_train_resized = np.array(X_train_resized)
X_test_resized = np.array(X_test_resized)

X_train_resized = X_train_resized / 255.0
X_test_resized = X_test_resized / 255.0

X_train_resized = preprocess_data(X_train_resized)
X_test_resized = preprocess_data(X_test_resized)

#@title
import cv2
```

```
X_train_new = list()

for i in range(len(X_train_resized)):
  g  = X_train_resized[i]
  X_train_new.append(cv2.merge([g,g,g]))

X_train_new = np.asarray(X_train_new,dtype=np.float32)

X_test_new = list()

for i in range(len(X_test_resized)):
  g  = X_test_resized[i]
  X_test_new.append(cv2.merge([g,g,g]))

X_test_new = np.asarray(X_test_new,dtype=np.float32)

#@title
model = VGG16(include_top=True, weights='imagenet')

model.compile(optimizer='SGD',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(X_train_new, y_train, epochs=5)

#@title
model.evaluate(X_test_new, y_test)

# SAVEE Dataset

#@title
```

```
!unzip "/content/drive/MyDrive/SaveeDataset.zip"

#@title
import librosa
import numpy as np

input_length = 16000*5

batch_size = 32

n_mels = 320

def preprocess_audio_mel_T(audio, sample_rate=16000, window_size=20,
#log_specgram
                step_size=10, eps=1e-10):

        mel_spec = librosa.feature.melspectrogram(y=audio, sr=sample_rate,
n_mels= n_mels)
        mel_db = (librosa.power_to_db(mel_spec, ref=np.max) + 40)/40

        return mel_db.T


def load_audio_file(file_path, input_length=input_length):
  data = librosa.core.load(file_path, sr=16000)[0] #, sr=16000
  if len(data)>input_length:
        max_offset = len(data)-input_length

        offset = np.random.randint(max_offset)

        data = data[offset:(input_length+offset)]
```

```
  else:
        if input_length > len(data):
        max_offset = input_length - len(data)

        offset = np.random.randint(max_offset)
        else:
        offset = 0
        data = np.pad(data, (offset, input_length - len(data) - offset), "constant")

  data = preprocess_audio_mel_T(data)
  return data

#@title
# Preprocessing the dataset
import os
from scipy.io import wavfile
import librosa
import matplotlib.pyplot as plt
import numpy as np
import cv2

rootDirectory = "/content/AudioData/"
personNames = ["DC","JE","JK","KL"]

classes = ["a" , "d" , "f", "h", "n", "sa" , "su" ]

X = list()
y = list()

for person in personNames:
  directory = os.path.join(rootDirectory,person)
  for filename in os.listdir(directory):
```

```
        filePath = os.path.join(directory, filename)
        a = load_audio_file(file_path=filePath)
        data = cv2.merge([a,a,a])
        # data = np.reshape(data, data.shape + (1,))
        if(filename[0:1] in classes):
        X.append(data)
        y.append(classes.index(filename[0:1]))
        elif(filename[0:2] in classes):
        X.append(data)
        y.append(classes.index(filename[0:2]))

#@title
X = np.asarray(X, dtype=np.float32)
y = np.asarray(y, dtype=np.float32)

#@title
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf

# dataset preparation

from tensorflow.keras import datasets,layers,models
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.5, train_size= 0.5
,random_state=10)

#@title
X_train_resized = load_preprocess_training_batch(X_train)
X_test_resized = load_preprocess_training_batch(X_test)
```

```
X_train_resized = np.array(X_train_resized)
X_test_resized = np.array(X_test_resized)

X_train_resized = preprocess_data(X_train_resized)
X_test_resized = preprocess_data(X_test_resized)

#@title
model = VGG16(include_top=True, weights='imagenet')

model.compile(optimizer='SGD',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(X_train_resized, y_train, epochs=50)

#@title
model.evaluate(X_test_resized, y_test)

# EmoDb Dataset

#@title
!unzip "/content/drive/MyDrive/EmoDB.zip"

#@title
import librosa
import numpy as np

input_length = 16000*5

batch_size = 32

n_mels = 320
```

```
def preprocess_audio_mel_T(audio, sample_rate=16000, window_size=20,
#log_specgram
                 step_size=10, eps=1e-10):

        mel_spec = librosa.feature.melspectrogram(y=audio, sr=sample_rate,
n_mels= n_mels)
        mel_db = (librosa.power_to_db(mel_spec, ref=np.max) + 40)/40

        return mel_db.T


def load_audio_file(file_path, input_length=input_length):
  data = librosa.core.load(file_path, sr=16000)[0] #, sr=16000
  if len(data)>input_length:
        max_offset = len(data)-input_length

        offset = np.random.randint(max_offset)

        data = data[offset:(input_length+offset)]

  else:
        if input_length > len(data):
        max_offset = input_length - len(data)

        offset = np.random.randint(max_offset)
        else:
        offset = 0
        data = np.pad(data, (offset, input_length - len(data) - offset), "constant")

  data = preprocess_audio_mel_T(data)
  return data
```

```
#@title
# Preprocessing the dataset
import os
from scipy.io import wavfile
import librosa
import matplotlib.pyplot as plt
import numpy as np
import cv2

directory = "/content/wav/"

classes = ["W" ,"L" ,"E" ,"A" , "F" ,"T" ,"N" ]

X = list()
y = list()

for filename in os.listdir(directory):
  filePath = os.path.join(directory, filename)
  a = load_audio_file(file_path=filePath)
  data = cv2.merge([a,a,a])
  if(filename[5:6] in classes):
        X.append(data)
        y.append(classes.index(filename[5:6]))

#@title
X = np.asarray(X, dtype=np.float32)
y = np.asarray(y, dtype=np.float32)

#@title
import pandas as pd
import numpy as np
```

```
import matplotlib.pyplot as plt
import tensorflow as tf

# dataset preparation

from tensorflow.keras import datasets,layers,models
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.5, train_size= 0.5
,random_state=10)

#@title
X_train_resized = load_preprocess_training_batch(X_train)
X_test_resized = load_preprocess_training_batch(X_test)

X_train_resized = np.array(X_train_resized)
X_test_resized = np.array(X_test_resized)

X_train_resized = preprocess_data(X_train_resized)
X_test_resized = preprocess_data(X_test_resized)

#@title
model = VGG16(include_top=True, weights='imagenet')

model.compile(optimizer='SGD',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(X_train_resized, y_train, epochs=20)

#@title
model.evaluate(X_test_resized, y_test)
from google.colab import drive
```

```
drive.mount('/content/drive')

from __future__ import print_function

import numpy as np
import warnings

!pip install keras_applications

from keras.layers import Input
from keras import layers
from keras.layers import Dense
from keras.layers import Activation
from keras.layers import Flatten
from keras.layers import Conv2D
from keras.layers import MaxPooling2D
from keras.layers import GlobalMaxPooling2D
from keras.layers import ZeroPadding2D
from keras.layers import AveragePooling2D
from keras.layers import GlobalAveragePooling2D
from keras.layers import BatchNormalization
from keras.models import Model
from keras.preprocessing import image
import keras.backend as K
from keras.utils import layer_utils
from keras.utils.data_utils import get_file
from keras.applications.imagenet_utils import decode_predictions
from keras.applications.imagenet_utils import preprocess_input
from keras_applications.imagenet_utils import _obtain_input_shape
from keras.utils.layer_utils import get_source_inputs

import tensorflow as tf
```

```
from tensorflow import keras
import matplotlib.pyplot as plt
%matplotlib inline
import numpy as np
import skimage.transform

WEIGHTS_PATH = 'https://github.com/fchollet/deep-learning-
models/releases/download/v0.2/resnet50_weights_tf_dim_ordering_tf_kernels.h5'
WEIGHTS_PATH_NO_TOP = 'https://github.com/fchollet/deep-learning-
models/releases/download/v0.2/resnet50_weights_tf_dim_ordering_tf_kernels_not
op.h5'


def identity_block(input_tensor, kernel_size, filters, stage, block):
    """The identity block is the block that has no conv layer at shortcut.
    # Arguments
    input_tensor: input tensor
    kernel_size: defualt 3, the kernel size of middle conv layer at main path
    filters: list of integers, the filterss of 3 conv layer at main path
    stage: integer, current stage label, used for generating layer names
    block: 'a','b'..., current block label, used for generating layer names
    # Returns
    Output tensor for the block.
    """
    filters1, filters2, filters3 = filters
    if K.image_data_format() == 'channels_last':
    bn_axis = 3
    else:
    bn_axis = 1
    conv_name_base = 'res' + str(stage) + block + '_branch'
    bn_name_base = 'bn' + str(stage) + block + '_branch'
```

```
    x = Conv2D(filters1, (1, 1), name=conv_name_base + '2a')(input_tensor)
    x = BatchNormalization(axis=bn_axis, name=bn_name_base + '2a')(x)
    x = Activation('relu')(x)

    x = Conv2D(filters2, kernel_size,
               padding='same', name=conv_name_base + '2b')(x)
    x = BatchNormalization(axis=bn_axis, name=bn_name_base + '2b')(x)
    x = Activation('relu')(x)

    x = Conv2D(filters3, (1, 1), name=conv_name_base + '2c')(x)
    x = BatchNormalization(axis=bn_axis, name=bn_name_base + '2c')(x)

    x = layers.add([x, input_tensor])
    x = Activation('relu')(x)
    return x


def conv_block(input_tensor, kernel_size, filters, stage, block, strides=(2, 2)):
    """conv_block is the block that has a conv layer at shortcut
    # Arguments
    input_tensor: input tensor
    kernel_size: defualt 3, the kernel size of middle conv layer at main path
    filters: list of integers, the filterss of 3 conv layer at main path
    stage: integer, current stage label, used for generating layer names
    block: 'a','b'..., current block label, used for generating layer names
    # Returns
    Output tensor for the block.
    Note that from stage 3, the first conv layer at main path is with strides=(2,2)
    And the shortcut should have strides=(2,2) as well
    """
    filters1, filters2, filters3 = filters
    if K.image_data_format() == 'channels_last':
```

```
    bn_axis = 3
    else:
    bn_axis = 1
    conv_name_base = 'res' + str(stage) + block + '_branch'
    bn_name_base = 'bn' + str(stage) + block + '_branch'

    x = Conv2D(filters1, (1, 1), strides=strides,
        name=conv_name_base + '2a')(input_tensor)
    x = BatchNormalization(axis=bn_axis, name=bn_name_base + '2a')(x)
    x = Activation('relu')(x)

    x = Conv2D(filters2, kernel_size, padding='same',
        name=conv_name_base + '2b')(x)
    x = BatchNormalization(axis=bn_axis, name=bn_name_base + '2b')(x)
    x = Activation('relu')(x)

    x = Conv2D(filters3, (1, 1), name=conv_name_base + '2c')(x)
    x = BatchNormalization(axis=bn_axis, name=bn_name_base + '2c')(x)

    shortcut = Conv2D(filters3, (1, 1), strides=strides,
        name=conv_name_base + '1')(input_tensor)
    shortcut = BatchNormalization(axis=bn_axis, name=bn_name_base +
'1')(shortcut)

    x = layers.add([x, shortcut])
    x = Activation('relu')(x)
    return x


def ResNet50(include_top=True, weights='imagenet',
    input_tensor=None, input_shape=None,
    pooling=None,
```

```
classes=1000):
"""Instantiates the ResNet50 architecture.
Optionally loads weights pre-trained
on ImageNet. Note that when using TensorFlow,
for best performance you should set
`image_data_format="channels_last"` in your Keras config
at ~/.keras/keras.json.
The model and the weights are compatible with both
TensorFlow and Theano. The data format
convention used by the model is the one
specified in your Keras config file.
# Arguments
include_top: whether to include the fully-connected
layer at the top of the network.
weights: one of `None` (random initialization)
or "imagenet" (pre-training on ImageNet).
input_tensor: optional Keras tensor (i.e. output of `layers.Input()`)
to use as image input for the model.
input_shape: optional shape tuple, only to be specified
if `include_top` is False (otherwise the input shape
has to be `(224, 224, 3)` (with `channels_last` data format)
or `(3, 224, 244)` (with `channels_first` data format).
It should have exactly 3 inputs channels,
and width and height should be no smaller than 197.
E.g. `(200, 200, 3)` would be one valid value.
pooling: Optional pooling mode for feature extraction
when `include_top` is `False`.
- `None` means that the output of the model will be
        the 4D tensor output of the
        last convolutional layer.
- `avg` means that global average pooling
        will be applied to the output of the
```

```
        last convolutional layer, and thus
        the output of the model will be a 2D tensor.
- `max` means that global max pooling will
        be applied.
classes: optional number of classes to classify images
into, only to be specified if `include_top` is True, and
if no `weights` argument is specified.
# Returns
A Keras model instance.
# Raises
ValueError: in case of invalid argument for `weights`,
or invalid input shape.
"""
if weights not in {'imagenet', None}:
raise ValueError('The `weights` argument should be either '
                '`None` (random initialization) or `imagenet` '
                '(pre-training on ImageNet).')

if weights == 'imagenet' and include_top and classes != 1000:
raise ValueError('If using `weights` as imagenet with `include_top`'
                ' as true, `classes` should be 1000')

# Determine proper input shape
input_shape = _obtain_input_shape(input_shape,
                        default_size=224,
                        min_size=197,
                        data_format=K.image_data_format(),
                        require_flatten=include_top)

if input_tensor is None:
img_input = Input(shape=input_shape)
else:
```

```
if not K.is_keras_tensor(input_tensor):
img_input = Input(tensor=input_tensor, shape=input_shape)
else:
img_input = input_tensor
if K.image_data_format() == 'channels_last':
bn_axis = 3
else:
bn_axis = 1

x = ZeroPadding2D((3, 3))(img_input)
x = Conv2D(64, (7, 7), strides=(2, 2), name='conv1')(x)
x = BatchNormalization(axis=bn_axis, name='bn_conv1')(x)
x = Activation('relu')(x)
x = MaxPooling2D((3, 3), strides=(2, 2))(x)

x = conv_block(x, 3, [64, 64, 256], stage=2, block='a', strides=(1, 1))
x = identity_block(x, 3, [64, 64, 256], stage=2, block='b')
x = identity_block(x, 3, [64, 64, 256], stage=2, block='c')

x = conv_block(x, 3, [128, 128, 512], stage=3, block='a')
x = identity_block(x, 3, [128, 128, 512], stage=3, block='b')
x = identity_block(x, 3, [128, 128, 512], stage=3, block='c')
x = identity_block(x, 3, [128, 128, 512], stage=3, block='d')

x = conv_block(x, 3, [256, 256, 1024], stage=4, block='a')
x = identity_block(x, 3, [256, 256, 1024], stage=4, block='b')
x = identity_block(x, 3, [256, 256, 1024], stage=4, block='c')
x = identity_block(x, 3, [256, 256, 1024], stage=4, block='d')
x = identity_block(x, 3, [256, 256, 1024], stage=4, block='e')
x = identity_block(x, 3, [256, 256, 1024], stage=4, block='f')

x = conv_block(x, 3, [512, 512, 2048], stage=5, block='a')
```

```
x = identity_block(x, 3, [512, 512, 2048], stage=5, block='b')
x = identity_block(x, 3, [512, 512, 2048], stage=5, block='c')

x = AveragePooling2D((7, 7), name='avg_pool')(x)

if include_top:
x = Flatten()(x)
x = Dense(classes, activation='softmax', name='fc1000')(x)
else:
if pooling == 'avg':
x = GlobalAveragePooling2D()(x)
elif pooling == 'max':
x = GlobalMaxPooling2D()(x)

# Ensure that the model takes into account
# any potential predecessors of `input_tensor`.
if input_tensor is not None:
inputs = get_source_inputs(input_tensor)
else:
inputs = img_input
# Create model.
model = Model(inputs, x, name='resnet50')

# load weights
if weights == 'imagenet':
if include_top:
weights_path = get_file('resnet50_weights_tf_dim_ordering_tf_kernels.h5',
                        WEIGHTS_PATH,
                        cache_subdir='models',
                        md5_hash='a7b3fe01876f51b976af0dea6bc144eb')
else:
```

```
    weights_path =
get_file('resnet50_weights_tf_dim_ordering_tf_kernels_notop.h5',
                        WEIGHTS_PATH_NO_TOP,
                        cache_subdir='models',
                        md5_hash='a268eb855778b3df3c7506639542a6af')
    model.load_weights(weights_path)
    if K.backend() == 'theano':
    layer_utils.convert_all_kernels_in_model(model)

    if K.image_data_format() == 'channels_first':
    if include_top:
        maxpool = model.get_layer(name='avg_pool')
        shape = maxpool.output_shape[1:]
        dense = model.get_layer(name='fc1000')
        layer_utils.convert_dense_weights_data_format(dense, shape,
'channels_first')

    if K.backend() == 'tensorflow':
        warnings.warn('You are using the TensorFlow backend, yet you '
            'are using the Theano '
            'image data format convention '
            '(`image_data_format="channels_first"`). '
            'For best performance, set '
            '`image_data_format="channels_last"` in '
            'your Keras config '
            'at ~/.keras/keras.json.')
    return model

def load_preprocess_training_batch(X_train):

    new = []
```

```
    for item in X_train:
    tmpFeature = skimage.transform.resize(item, (224, 224), mode='constant')
    new.append(tmpFeature)

    return new

def preprocess_data(X_train):

    for item in X_train:
    item = np.expand_dims(item, axis=0)
    item = preprocess_input(item)

    return X_train

# CIFAR-10 DATASET

(X_train, y_train) , (X_test, y_test) = keras.datasets.cifar10.load_data()

X_train = X_train[0:2000]
y_train = y_train[0:2000]
X_test = X_test[0:2000]
y_test = y_test[0:2000]

X_train_resized = load_preprocess_training_batch(X_train)
X_test_resized = load_preprocess_training_batch(X_test)

X_train_resized = np.array(X_train_resized)
X_test_resized = np.array(X_test_resized)

X_train_resized = X_train_resized / 255
X_test_resized = X_test_resized / 255
```

```
X_train_resized = preprocess_data(X_train_resized)
X_test_resized = preprocess_data(X_test_resized)

model = ResNet50(include_top=True, weights='imagenet')

model.compile(optimizer='SGD',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(X_train_resized, y_train, epochs=5)

model.evaluate(X_test_resized, y_test)

# MNIST Dataset

(X_train, y_train) , (X_test, y_test) = keras.datasets.mnist.load_data()

X_train = X_train[0:2000]
y_train = y_train[0:2000]
X_test = X_test[0:2000]
y_test = y_test[0:2000]

X_train_resized = load_preprocess_training_batch(X_train)
X_test_resized = load_preprocess_training_batch(X_test)

X_train_resized = np.array(X_train_resized)
X_test_resized = np.array(X_test_resized)

X_train_resized = X_train_resized / 255.0
X_test_resized = X_test_resized / 255.0

X_train_resized = preprocess_data(X_train_resized)
```

```
X_test_resized = preprocess_data(X_test_resized)

import cv2

X_train_new = list()

for i in range(len(X_train_resized)):
  g  = X_train_resized[i]
  X_train_new.append(cv2.merge([g,g,g]))

X_train_new = np.asarray(X_train_new,dtype=np.float32)

X_test_new = list()

for i in range(len(X_test_resized)):
  g  = X_test_resized[i]
  X_test_new.append(cv2.merge([g,g,g]))

X_test_new = np.asarray(X_test_new,dtype=np.float32)

model = ResNet50(include_top=True, weights='imagenet')

model.compile(optimizer='SGD',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(X_train_new, y_train, epochs=10)

model.evaluate(X_test_new, y_test)

# SAVEE Dataset
```

```
!unzip "/content/drive/MyDrive/SaveeDataset.zip"

import librosa
import numpy as np

input_length = 16000*5

batch_size = 32

n_mels = 320

def preprocess_audio_mel_T(audio, sample_rate=16000, window_size=20,
#log_specgram
                step_size=10, eps=1e-10):

        mel_spec = librosa.feature.melspectrogram(y=audio, sr=sample_rate,
n_mels= n_mels)
        mel_db = (librosa.power_to_db(mel_spec, ref=np.max) + 40)/40

        return mel_db.T


def load_audio_file(file_path, input_length=input_length):
  data = librosa.core.load(file_path, sr=16000)[0] #, sr=16000
  if len(data)>input_length:
        max_offset = len(data)-input_length

        offset = np.random.randint(max_offset)

        data = data[offset:(input_length+offset)]

  else:
```

```
    if input_length > len(data):
    max_offset = input_length - len(data)

    offset = np.random.randint(max_offset)
    else:
    offset = 0
    data = np.pad(data, (offset, input_length - len(data) - offset), "constant")

  data = preprocess_audio_mel_T(data)
  return data

# Preprocessing the dataset
import os
from scipy.io import wavfile
import librosa
import matplotlib.pyplot as plt
import numpy as np
import cv2

rootDirectory = "/content/AudioData/"
personNames = ["DC","JE","JK","KL"]

classes = ["a" , "d" , "f", "h", "n", "sa" , "su" ]

X = list()
y = list()

for person in personNames:
  directory = os.path.join(rootDirectory,person)
  for filename in os.listdir(directory):
    filePath = os.path.join(directory, filename)
    a = load_audio_file(file_path=filePath)
```

```
        data = cv2.merge([a,a,a])
        # data = np.reshape(data, data.shape + (1,))
        if(filename[0:1] in classes):
        X.append(data)
        y.append(classes.index(filename[0:1]))
        elif(filename[0:2] in classes):
        X.append(data)
        y.append(classes.index(filename[0:2]))

X = np.asarray(X, dtype=np.float32)
y = np.asarray(y, dtype=np.float32)

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf

# dataset preparation

from tensorflow.keras import datasets,layers,models
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.5, train_size= 0.5
,random_state=10)

X_train_resized = load_preprocess_training_batch(X_train)
X_test_resized = load_preprocess_training_batch(X_test)

X_train_resized = np.array(X_train_resized)
X_test_resized = np.array(X_test_resized)

X_train_resized = preprocess_data(X_train_resized)
X_test_resized = preprocess_data(X_test_resized)
```

```
model = ResNet50(include_top=True, weights='imagenet')

model.compile(optimizer='SGD',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(X_train_resized, y_train, epochs=10)

model.evaluate(X_test_resized, y_test)

# EmoDB Dataset

!unzip "/content/drive/MyDrive/EmoDB.zip"

import librosa
import numpy as np

input_length = 16000*5

batch_size = 32

n_mels = 320

def preprocess_audio_mel_T(audio, sample_rate=16000, window_size=20,
#log_specgram
              step_size=10, eps=1e-10):

    mel_spec = librosa.feature.melspectrogram(y=audio, sr=sample_rate,
n_mels= n_mels)
    mel_db = (librosa.power_to_db(mel_spec, ref=np.max) + 40)/40
```

```
        return mel_db.T


def load_audio_file(file_path, input_length=input_length):
  data = librosa.core.load(file_path, sr=16000)[0] #, sr=16000
  if len(data)>input_length:
        max_offset = len(data)-input_length

        offset = np.random.randint(max_offset)

        data = data[offset:(input_length+offset)]

  else:
        if input_length > len(data):
        max_offset = input_length - len(data)

        offset = np.random.randint(max_offset)
        else:
        offset = 0
        data = np.pad(data, (offset, input_length - len(data) - offset), "constant")

  data = preprocess_audio_mel_T(data)
  return data

# Preprocessing the dataset
import os
from scipy.io import wavfile
import librosa
import matplotlib.pyplot as plt
import numpy as np
import cv2
```

```
directory = "/content/wav/"

classes = ["W" ,"L" ,"E" ,"A" , "F" ,"T" ,"N" ]

X = list()
y = list()

for filename in os.listdir(directory):
  filePath = os.path.join(directory, filename)
  a = load_audio_file(file_path=filePath)
  data = cv2.merge([a,a,a])
  if(filename[5:6] in classes):
        X.append(data)
        y.append(classes.index(filename[5:6]))

X = np.asarray(X, dtype=np.float32)
y = np.asarray(y, dtype=np.float32)

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf

# dataset preparation

from tensorflow.keras import datasets,layers,models
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.5, train_size= 0.5
,random_state=10)

X_train_resized = load_preprocess_training_batch(X_train)
X_test_resized = load_preprocess_training_batch(X_test)
```

```
X_train_resized = np.array(X_train_resized)
X_test_resized = np.array(X_test_resized)

X_train_resized = preprocess_data(X_train_resized)
X_test_resized = preprocess_data(X_test_resized)

model = ResNet50(include_top=True, weights='imagenet')

model.compile(optimizer='SGD',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(X_train_resized, y_train, epochs=10)

model.evaluate(X_test_resized, y_test)#@title
from google.colab import drive
drive.mount('/content/drive')

# CIFAR 10 DATASET

#@title
import os
import tensorflow as tf
import keras
from tensorflow.keras import layers
from tensorflow.keras import Model
from os import getcwd

#@title
cifar10 = tf.keras.datasets.cifar10
(training_images, training_labels), (test_images, test_labels) = cifar10.load_data()
```

```
#@title
print(len(training_images))
print(len(test_images))

#@title
training_images = training_images.reshape(50000, 1024, 3)
training_images = training_images[0:10000]
training_labels = training_labels[0:10000]
training_images = training_images/255.0
test_images = test_images.reshape(10000, 1024, 3)
test_images = test_images[0:5000]
test_labels = test_labels[0:5000]
test_images = test_images/255.0

#@title
model = tf.keras.models.Sequential([
    tf.keras.layers.Bidirectional(tf.keras.layers.LSTM(32, input_shape=(1024,3),
return_sequences=True)),
    tf.keras.layers.Bidirectional(tf.keras.layers.LSTM(32)),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(64, activation='relu'),
    tf.keras.layers.Dense(10, activation='softmax')
    ])

#@title
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(training_images, training_labels, batch_size = 50, epochs=10)
```

```
#@title
model.evaluate(test_images, test_labels)

# MNIST DATASET

#@title
import torch

#@title
# Device configuration
device = torch.device('cuda' if torch.cuda.is_available() else 'cpu')
device

#@title
from torchvision import datasets
from torchvision.transforms import ToTensor
train_data = datasets.MNIST(
        root = 'data',
        train = True,
        transform = ToTensor(),
        download = True,
)
test_data = datasets.MNIST(
        root = 'data',
        train = False,
        transform = ToTensor()
)


#@title
print(train_data)
```

```
#@title
print(test_data)


#@title
print(train_data.data.size())


#@title
print(train_data.targets.size())


#@title
print(train_data.data[0])


#@title
import matplotlib.pyplot as plt
plt.imshow(train_data.data[0], cmap='gray')
plt.title('%i' % train_data.targets[0])
plt.show()


#@title
figure = plt.figure(figsize=(10, 8))
cols, rows = 5, 5
for i in range(1, cols * rows + 1):
    sample_idx = torch.randint(len(train_data), size=(1,)).item()
    img, label = train_data[sample_idx]
    figure.add_subplot(rows, cols, i)
    plt.title(label)
```

```
        plt.axis("off")
        plt.imshow(img.squeeze(), cmap="gray")
plt.show()


#@title
from torch.utils.data import DataLoader
loaders = {
        'train' : torch.utils.data.DataLoader(train_data,
                                              batch_size=100,
                                              shuffle=True,
                                              num_workers=1),

        'test'  : torch.utils.data.DataLoader(test_data,
                                              batch_size=100,
                                              shuffle=True,
                                              num_workers=1),
}
loaders

#@title
from torch import nn
import torch.nn.functional as F


#@title
sequence_length = 28
input_size = 28
hidden_size = 128
num_layers = 2
num_classes = 10
batch_size = 100
```

```
num_epochs = 2
learning_rate = 0.01


#@title
class RNN(nn.Module):
        pass
model = RNN().to(device)
print(model)


#@title
class RNN(nn.Module):

        def __init__(self, input_size, hidden_size, num_layers, num_classes):
        super(RNN, self).__init__()
        self.hidden_size = hidden_size
        self.num_layers = num_layers
        self.lstm = nn.LSTM(input_size, hidden_size, num_layers, batch_first=True)
        self.fc = nn.Linear(hidden_size, num_classes)
        pass

        def forward(self, x):
        # Set initial hidden and cell states
        h0 = torch.zeros(self.num_layers, x.size(0), self.hidden_size).to(device)
        c0 = torch.zeros(self.num_layers, x.size(0), self.hidden_size).to(device)
        # Passing in the input and hidden state into the model and  obtaining outputs
        out, hidden = self.lstm(x, (h0, c0))  # out: tensor of shape (batch_size, 
seq_length, hidden_size)

        #Reshaping the outputs such that it can be fit into the fully connected layer
        out = self.fc(out[:, -1, :])
```

```
        return out

        pass
pass
model = RNN(input_size, hidden_size, num_layers, num_classes).to(device)
print(model)


#@title
loss_func = nn.CrossEntropyLoss()
loss_func

#@title
from torch import optim
optimizer = optim.Adam(model.parameters(), lr = 0.01)
optimizer

#@title
def train(num_epochs, model, loaders):

        # Train the model
        total_step = len(loaders['train'])

        for epoch in range(num_epochs):
        for i, (images, labels) in enumerate(loaders['train']):

        images = images.reshape(-1, sequence_length, input_size).to(device)
        labels = labels.to(device)

        # Forward pass
        outputs = model(images)
        loss = loss_func(outputs, labels)
```

```
        # Backward and optimize
        optimizer.zero_grad()
        loss.backward()
        optimizer.step()

        if (i+1) % 100 == 0:
                print ('Epoch [{}/{}], Step [{}/{}], Loss: {:.4f}'
                .format(epoch + 1, num_epochs, i + 1, total_step, loss.item()))
                pass

        pass
        pass
train(num_epochs, model, loaders)

#@title
# Test the model
model.eval()
with torch.no_grad():
        correct = 0
        total = 0
        for images, labels in loaders['test']:
        images = images.reshape(-1, sequence_length, input_size).to(device)
        labels = labels.to(device)
        outputs = model(images)
        _, predicted = torch.max(outputs.data, 1)
        total = total + labels.size(0)
        correct = correct + (predicted == labels).sum().item()
print('Test Accuracy of the model on the 10000 test images: {} %'.format(100 *
correct / total))

# SAVEE Dataset
```

```
#@title
!unzip "/content/drive/MyDrive/SaveeDataset.zip"

#@title
import librosa
import numpy as np

input_length = 16000*5

batch_size = 32

n_mels = 320

def preprocess_audio_mel_T(audio, sample_rate=16000, window_size=20,
#log_specgram
                 step_size=10, eps=1e-10):

        mel_spec = librosa.feature.melspectrogram(y=audio, sr=sample_rate,
n_mels= n_mels)
        mel_db = (librosa.power_to_db(mel_spec, ref=np.max) + 40)/40

        return mel_db.T


def load_audio_file(file_path, input_length=input_length):
  data = librosa.core.load(file_path, sr=16000)[0] #, sr=16000
  if len(data)>input_length:
        max_offset = len(data)-input_length

        offset = np.random.randint(max_offset)

        data = data[offset:(input_length+offset)]
```

```
  else:
        if input_length > len(data):
        max_offset = input_length - len(data)

        offset = np.random.randint(max_offset)
        else:
        offset = 0
        data = np.pad(data, (offset, input_length - len(data) - offset), "constant")

  data = preprocess_audio_mel_T(data)
  return data

#@title
# Preprocessing the dataset
import os
from scipy.io import wavfile
import librosa
import matplotlib.pyplot as plt
import numpy as np
import cv2

rootDirectory = "/content/AudioData/"
personNames = ["DC","JE","JK","KL"]

classes = ["a" , "d" , "f", "h", "n", "sa" , "su" ]

X = list()
y = list()

for person in personNames:
  directory = os.path.join(rootDirectory,person)
```

```
  for filename in os.listdir(directory):
        filePath = os.path.join(directory, filename)
        data = load_audio_file(file_path=filePath)
        # data = cv2.merge([a,a,a])
        if(filename[0:1] in classes):
        X.append(data)
        y.append(classes.index(filename[0:1]))
        elif(filename[0:2] in classes):
        X.append(data)
        y.append(classes.index(filename[0:2]))

#@title
X = np.asarray(X, dtype=np.float32)
y = np.asarray(y, dtype=np.float32)

#@title
X.shape , y.shape

#@title
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf

# dataset preparation

from tensorflow.keras import datasets,layers,models
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.4, train_size= 0.6
,random_state=10)

#@title
```

```
import os
import tensorflow as tf
import keras
from tensorflow.keras import layers
from tensorflow.keras import Model
from os import getcwd

#@title
model = tf.keras.models.Sequential([
   tf.keras.layers.Bidirectional(tf.keras.layers.LSTM(32, input_shape=(157,320),
return_sequences=True)),
   tf.keras.layers.Bidirectional(tf.keras.layers.LSTM(32)),
   tf.keras.layers.Flatten(),
   tf.keras.layers.Dense(64, activation='relu'),
   tf.keras.layers.Dense(10, activation='softmax')
   ])

#@title
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(X_train,y_train, batch_size = 50, epochs=50)

#@title
model.evaluate(X_test, y_test)

# EmoDB Dataset

#@title
!unzip "/content/drive/MyDrive/EmoDB.zip"
```

```
#@title
import librosa
import numpy as np

input_length = 16000*5

batch_size = 32

n_mels = 320

def preprocess_audio_mel_T(audio, sample_rate=16000, window_size=20,
#log_specgram
                 step_size=10, eps=1e-10):

        mel_spec = librosa.feature.melspectrogram(y=audio, sr=sample_rate,
n_mels= n_mels)
        mel_db = (librosa.power_to_db(mel_spec, ref=np.max) + 40)/40

        return mel_db.T


def load_audio_file(file_path, input_length=input_length):
  data = librosa.core.load(file_path, sr=16000)[0] #, sr=16000
  if len(data)>input_length:
        max_offset = len(data)-input_length

        offset = np.random.randint(max_offset)

        data = data[offset:(input_length+offset)]

  else:
        if input_length > len(data):
```

```
        max_offset = input_length - len(data)

        offset = np.random.randint(max_offset)
        else:
        offset = 0
        data = np.pad(data, (offset, input_length - len(data) - offset), "constant")

  data = preprocess_audio_mel_T(data)
  return data

#@title
# Preprocessing the dataset
import os
from scipy.io import wavfile
import librosa
import matplotlib.pyplot as plt
import numpy as np
import cv2

directory = "/content/wav/"

classes = ["W" ,"L" ,"E" ,"A" , "F" ,"T" ,"N" ]

X = list()
y = list()

for filename in os.listdir(directory):
  filePath = os.path.join(directory, filename)
  data = load_audio_file(file_path=filePath)
  if(filename[5:6] in classes):
        X.append(data)
        y.append(classes.index(filename[5:6]))
```

```
#@title
X = np.asarray(X, dtype=np.float32)
y = np.asarray(y, dtype=np.float32)

#@title
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf

# dataset preparation

from tensorflow.keras import datasets,layers,models
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, train_size= 0.7
,random_state=10)

#@title
model = tf.keras.models.Sequential([
   tf.keras.layers.Bidirectional(tf.keras.layers.LSTM(32, input_shape=(157,320),
return_sequences=True)),
   tf.keras.layers.Bidirectional(tf.keras.layers.LSTM(32)),
   tf.keras.layers.Flatten(),
   tf.keras.layers.Dense(64, activation='relu'),
   tf.keras.layers.Dense(10, activation='softmax')
   ])

#@title
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])
```

```
history = model.fit(X_train,y_train, batch_size = 50, epochs=50)

#@title
model.evaluate(X_test, y_test)from google.colab import drive
drive.mount('/content/drive')

# CIFAR 10 DATASET

def inception_module(x,
                filters_1x1,
                filters_3x3_reduce,
                filters_3x3,
                filters_5x5_reduce,
                filters_5x5,
                filters_pool_proj,
                name=None):

        conv_1x1 = Conv2D(filters_1x1, (1, 1), padding='same', activation='relu',
kernel_initializer=kernel_init, bias_initializer=bias_init)(x)

        conv_3x3 = Conv2D(filters_3x3_reduce, (1, 1), padding='same',
activation='relu', kernel_initializer=kernel_init, bias_initializer=bias_init)(x)
        conv_3x3 = Conv2D(filters_3x3, (3, 3), padding='same', activation='relu',
kernel_initializer=kernel_init, bias_initializer=bias_init)(conv_3x3)

        conv_5x5 = Conv2D(filters_5x5_reduce, (1, 1), padding='same',
activation='relu', kernel_initializer=kernel_init, bias_initializer=bias_init)(x)
        conv_5x5 = Conv2D(filters_5x5, (5, 5), padding='same', activation='relu',
kernel_initializer=kernel_init, bias_initializer=bias_init)(conv_5x5)

        pool_proj = MaxPool2D((3, 3), strides=(1, 1), padding='same')(x)
```

```
    pool_proj = Conv2D(filters_pool_proj, (1, 1), padding='same',
activation='relu', kernel_initializer=kernel_init,
bias_initializer=bias_init)(pool_proj)

    output = concatenate([conv_1x1, conv_3x3, conv_5x5, pool_proj], axis=3,
name=name)

    return output

kernel_init = keras.initializers.glorot_uniform()
bias_init = keras.initializers.Constant(value=0.2)

input_layer = Input(shape=(224, 224, 3))

x = Conv2D(64, (7, 7), padding='same', strides=(2, 2), activation='relu',
name='conv_1_7x7/2', kernel_initializer=kernel_init,
bias_initializer=bias_init)(input_layer)
x = MaxPool2D((3, 3), padding='same', strides=(2, 2),
name='max_pool_1_3x3/2')(x)
x = Conv2D(64, (1, 1), padding='same', strides=(1, 1), activation='relu',
name='conv_2a_3x3/1')(x)
x = Conv2D(192, (3, 3), padding='same', strides=(1, 1), activation='relu',
name='conv_2b_3x3/1')(x)
x = MaxPool2D((3, 3), padding='same', strides=(2, 2),
name='max_pool_2_3x3/2')(x)

x = inception_module(x,
        filters_1x1=64,
        filters_3x3_reduce=96,
        filters_3x3=128,
        filters_5x5_reduce=16,
        filters_5x5=32,
```

```
                    filters_pool_proj=32,
                    name='inception_3a')

x = inception_module(x,
                    filters_1x1=128,
                    filters_3x3_reduce=128,
                    filters_3x3=192,
                    filters_5x5_reduce=32,
                    filters_5x5=96,
                    filters_pool_proj=64,
                    name='inception_3b')

x = MaxPool2D((3, 3), padding='same', strides=(2, 2),
name='max_pool_3_3x3/2')(x)

x = inception_module(x,
                    filters_1x1=192,
                    filters_3x3_reduce=96,
                    filters_3x3=208,
                    filters_5x5_reduce=16,
                    filters_5x5=48,
                    filters_pool_proj=64,
                    name='inception_4a')


x1 = AveragePooling2D((5, 5), strides=3)(x)
x1 = Conv2D(128, (1, 1), padding='same', activation='relu')(x1)
x1 = Flatten()(x1)
x1 = Dense(1024, activation='relu')(x1)
x1 = Dropout(0.7)(x1)
x1 = Dense(10, activation='softmax', name='auxilliary_output_1')(x1)
```

```
x = inception_module(x,
                     filters_1x1=160,
                     filters_3x3_reduce=112,
                     filters_3x3=224,
                     filters_5x5_reduce=24,
                     filters_5x5=64,
                     filters_pool_proj=64,
                     name='inception_4b')

x = inception_module(x,
                     filters_1x1=128,
                     filters_3x3_reduce=128,
                     filters_3x3=256,
                     filters_5x5_reduce=24,
                     filters_5x5=64,
                     filters_pool_proj=64,
                     name='inception_4c')

x = inception_module(x,
                     filters_1x1=112,
                     filters_3x3_reduce=144,
                     filters_3x3=288,
                     filters_5x5_reduce=32,
                     filters_5x5=64,
                     filters_pool_proj=64,
                     name='inception_4d')


x2 = AveragePooling2D((5, 5), strides=3)(x)
x2 = Conv2D(128, (1, 1), padding='same', activation='relu')(x2)
x2 = Flatten()(x2)
x2 = Dense(1024, activation='relu')(x2)
```

```
x2 = Dropout(0.7)(x2)
x2 = Dense(10, activation='softmax', name='auxilliary_output_2')(x2)

x = inception_module(x,
                filters_1x1=256,
                filters_3x3_reduce=160,
                filters_3x3=320,
                filters_5x5_reduce=32,
                filters_5x5=128,
                filters_pool_proj=128,
                name='inception_4e')

x = MaxPool2D((3, 3), padding='same', strides=(2, 2),
name='max_pool_4_3x3/2')(x)

x = inception_module(x,
                filters_1x1=256,
                filters_3x3_reduce=160,
                filters_3x3=320,
                filters_5x5_reduce=32,
                filters_5x5=128,
                filters_pool_proj=128,
                name='inception_5a')

x = inception_module(x,
                filters_1x1=384,
                filters_3x3_reduce=192,
                filters_3x3=384,
                filters_5x5_reduce=48,
                filters_5x5=128,
                filters_pool_proj=128,
                name='inception_5b')
```

```
x = GlobalAveragePooling2D(name='avg_pool_5_3x3/1')(x)

x = Dropout(0.4)(x)

x = Dense(10, activation='softmax', name='output')(x)


import keras
from keras.layers.core import Layer
import keras.backend as K
import tensorflow as tf
from keras.datasets import cifar10

from keras.models import Model

from keras.layers import Conv2D, MaxPool2D,  \
        Dropout, Dense, Input, concatenate,      \
        GlobalAveragePooling2D, AveragePooling2D,\
        Flatten

import cv2
import numpy as np
from keras.datasets import cifar10
from keras import backend as K
from keras.utils import np_utils

import math
from tensorflow.keras.optimizers import SGD
from keras.callbacks import LearningRateScheduler

num_classes = 10
```

```
def load_cifar10_data(img_rows, img_cols):

	# Load cifar10 training and validation sets
	(X_train, Y_train), (X_valid, Y_valid) = cifar10.load_data()

	X_train = X_train[0:5000]
	Y_train = Y_train[0:5000]
	X_valid = X_valid[0:2000]
	Y_valid = Y_valid[0:2000]

	# Resize training images
	X_train = np.array([cv2.resize(img, (img_rows,img_cols)) for img in
X_train[:,:,:,:]])
	X_valid = np.array([cv2.resize(img, (img_rows,img_cols)) for img in
X_valid[:,:,:,:]])

	# Transform targets to keras compatible format
	Y_train = np_utils.to_categorical(Y_train, num_classes)
	Y_valid = np_utils.to_categorical(Y_valid, num_classes)

	X_train = X_train.astype('float32')
	X_valid = X_valid.astype('float32')

	# preprocess data
	X_train = X_train / 255.0
	X_valid = X_valid / 255.0

	return X_train, Y_train, X_valid, Y_valid


X_train, y_train, X_test, y_test = load_cifar10_data(224, 224)
```

```
model = Model(input_layer, [x, x1, x2], name='inception_v1')

model.summary()

epochs = 10
initial_lrate = 0.01

def decay(epoch, steps=100):
	initial_lrate = 0.01
	drop = 0.96
	epochs_drop = 8
	lrate = initial_lrate * math.pow(drop, math.floor((1+epoch)/epochs_drop))
	return lrate

sgd = SGD(learning_rate=initial_lrate, momentum=0.9, nesterov=False)

lr_sc = LearningRateScheduler(decay, verbose=1)

model.compile(loss=['categorical_crossentropy', 'categorical_crossentropy',
'categorical_crossentropy'], loss_weights=[1, 0.3, 0.3], optimizer=sgd,
metrics=['accuracy'])

history = model.fit(X_train, [y_train, y_train, y_train], validation_data=(X_test,
[y_test, y_test, y_test]), epochs=epochs, batch_size=256, callbacks=[lr_sc])


# MNIST DATASET

import tensorflow as tf
import matplotlib.pyplot as plt
```

```
from tensorflow.keras import datasets, layers, models, losses, Model

(x_train, y_train), (x_test, y_test)=tf.keras.datasets.mnist.load_data()
x_train = tf.pad(x_train, [[0, 0], [2,2], [2,2]])/255
x_test = tf.pad(x_test, [[0, 0], [2,2], [2,2]])/255
x_train = tf.expand_dims(x_train, axis=3, name=None)
x_test = tf.expand_dims(x_test, axis=3, name=None)
x_train = tf.repeat(x_train, 3, axis=3)
x_test = tf.repeat(x_test, 3, axis=3)
x_val = x_train[-2000:,:,:]
y_val = y_train[-2000:]
x_train = x_train[:-2000,:,:]
y_train = y_train[:-2000]

def inception(x,
              filters_1x1,
              filters_3x3_reduce,
              filters_3x3,
              filters_5x5_reduce,
              filters_5x5,
              filters_pool):
  path1 = layers.Conv2D(filters_1x1, (1, 1), padding='same', activation='relu')(x)

  path2 = layers.Conv2D(filters_3x3_reduce, (1, 1), padding='same',
activation='relu')(x)
  path2 = layers.Conv2D(filters_3x3, (1, 1), padding='same',
activation='relu')(path2)

  path3 = layers.Conv2D(filters_5x5_reduce, (1, 1), padding='same',
activation='relu')(x)
  path3 = layers.Conv2D(filters_5x5, (1, 1), padding='same',
activation='relu')(path3)
```

```
  path4 = layers.MaxPool2D((3, 3), strides=(1, 1), padding='same')(x)
  path4 = layers.Conv2D(filters_pool, (1, 1), padding='same',
activation='relu')(path4)

  return tf.concat([path1, path2, path3, path4], axis=3)


inp = layers.Input(shape=(32, 32, 3))
input_tensor = layers.experimental.preprocessing.Resizing(224, 224,
interpolation="bilinear", input_shape=x_train.shape[1:])(inp)

x = layers.Conv2D(64, 7, strides=2, padding='same',
activation='relu')(input_tensor)
x = layers.MaxPooling2D(3, strides=2)(x)

x = layers.Conv2D(64, 1, strides=1, padding='same', activation='relu')(x)
x = layers.Conv2D(192, 3, strides=1, padding='same', activation='relu')(x)

x = layers.MaxPooling2D(3, strides=2)(x)

x = inception(x,
              filters_1x1=64,
              filters_3x3_reduce=96,
              filters_3x3=128,
              filters_5x5_reduce=16,
              filters_5x5=32,
              filters_pool=32)

x = inception(x,
              filters_1x1=128,
              filters_3x3_reduce=128,
```

```
                filters_3x3=192,
                filters_5x5_reduce=32,
                filters_5x5=96,
                filters_pool=64)

x = layers.MaxPooling2D(3, strides=2)(x)

x = inception(x,
                filters_1x1=192,
                filters_3x3_reduce=96,
                filters_3x3=208,
                filters_5x5_reduce=16,
                filters_5x5=48,
                filters_pool=64)

aux1 = layers.AveragePooling2D((5, 5), strides=3)(x)
aux1 = layers.Conv2D(128, 1, padding='same', activation='relu')(aux1)
aux1 = layers.Flatten()(aux1)
aux1 = layers.Dense(1024, activation='relu')(aux1)
aux1 = layers.Dropout(0.7)(aux1)
aux1 = layers.Dense(10, activation='softmax')(aux1)

x = inception(x,
                filters_1x1=160,
                filters_3x3_reduce=112,
                filters_3x3=224,
                filters_5x5_reduce=24,
                filters_5x5=64,
                filters_pool=64)

x = inception(x,
                filters_1x1=128,
```

```
                filters_3x3_reduce=128,
                filters_3x3=256,
                filters_5x5_reduce=24,
                filters_5x5=64,
                filters_pool=64)

x = inception(x,
                filters_1x1=112,
                filters_3x3_reduce=144,
                filters_3x3=288,
                filters_5x5_reduce=32,
                filters_5x5=64,
                filters_pool=64)

aux2 = layers.AveragePooling2D((5, 5), strides=3)(x)
aux2 = layers.Conv2D(128, 1, padding='same', activation='relu')(aux2)
aux2 = layers.Flatten()(aux2)
aux2 = layers.Dense(1024, activation='relu')(aux2)
aux2 = layers.Dropout(0.7)(aux2)
aux2 = layers.Dense(10, activation='softmax')(aux2)

x = inception(x,
                filters_1x1=256,
                filters_3x3_reduce=160,
                filters_3x3=320,
                filters_5x5_reduce=32,
                filters_5x5=128,
                filters_pool=128)

x = layers.MaxPooling2D(3, strides=2)(x)

x = inception(x,
```

```
                filters_1x1=256,
                filters_3x3_reduce=160,
                filters_3x3=320,
                filters_5x5_reduce=32,
                filters_5x5=128,
                filters_pool=128)

x = inception(x,
                filters_1x1=384,
                filters_3x3_reduce=192,
                filters_3x3=384,
                filters_5x5_reduce=48,
                filters_5x5=128,
                filters_pool=128)

x = layers.GlobalAveragePooling2D()(x)

x = layers.Dropout(0.4)(x)
out = layers.Dense(10, activation='softmax')(x)

model = Model(inputs = inp, outputs = [out, aux1, aux2])

model.compile(optimizer='adam', loss=[losses.sparse_categorical_crossentropy,
losses.sparse_categorical_crossentropy, losses.sparse_categorical_crossentropy],
loss_weights=[1, 0.3, 0.3], metrics=['accuracy'])


history = model.fit(x_train, [y_train, y_train, y_train], validation_data=(x_val,
[y_val, y_val, y_val]), batch_size=64, epochs=10)


fig, axs = plt.subplots(2, 1, figsize=(15,15))
```

```
axs[0].plot(history.history['loss'])
axs[0].plot(history.history['val_loss'])
axs[0].title.set_text('Training Loss vs Validation Loss')
axs[0].set_xlabel('Epochs')
axs[0].set_ylabel('Loss')
axs[0].legend(['Train','Val'])


model.evaluate(x_test, y_test)


# SAVEE Dataset

!unzip "/content/drive/MyDrive/SaveeDataset.zip"

import librosa
import numpy as np

input_length = 16000*5

batch_size = 32

n_mels = 320

def preprocess_audio_mel_T(audio, sample_rate=16000, window_size=20,
#log_specgram
                step_size=10, eps=1e-10):

        mel_spec = librosa.feature.melspectrogram(y=audio, sr=sample_rate,
n_mels= n_mels)
        mel_db = (librosa.power_to_db(mel_spec, ref=np.max) + 40)/40
```

```
        return mel_db.T


def load_audio_file(file_path, input_length=input_length):
  data = librosa.core.load(file_path, sr=16000)[0] #, sr=16000
  if len(data)>input_length:
        max_offset = len(data)-input_length

        offset = np.random.randint(max_offset)

        data = data[offset:(input_length+offset)]

  else:
        if input_length > len(data):
        max_offset = input_length - len(data)

        offset = np.random.randint(max_offset)
        else:
        offset = 0
        data = np.pad(data, (offset, input_length - len(data) - offset), "constant")

  data = preprocess_audio_mel_T(data)
  return data

# Preprocessing the dataset
import os
from scipy.io import wavfile
import librosa
import matplotlib.pyplot as plt
import numpy as np
import cv2
```

```
rootDirectory = "/content/AudioData/"
personNames = ["DC","JE","JK","KL"]

classes = ["a" , "d" , "f", "h", "n", "sa" , "su" ]

X = list()
y = list()

for person in personNames:
  directory = os.path.join(rootDirectory,person)
  for filename in os.listdir(directory):
        filePath = os.path.join(directory, filename)
        a = load_audio_file(file_path=filePath)
        data = cv2.merge([a,a,a])
        if(filename[0:1] in classes):
        X.append(data)
        y.append(classes.index(filename[0:1]))
        elif(filename[0:2] in classes):
        X.append(data)
        y.append(classes.index(filename[0:2]))

X = np.asarray(X, dtype=np.float32)
y = np.asarray(y, dtype=np.float32)

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf

# dataset preparation
```

```
from tensorflow.keras import datasets,layers,models
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.4, train_size= 0.6
,random_state=10)

import tensorflow as tf
import matplotlib.pyplot as plt
from tensorflow.keras import datasets, layers, models, losses, Model

def inception(x,
              filters_1x1,
              filters_3x3_reduce,
              filters_3x3,
              filters_5x5_reduce,
              filters_5x5,
              filters_pool):
  path1 = layers.Conv2D(filters_1x1, (1, 1), padding='same', activation='relu')(x)

  path2 = layers.Conv2D(filters_3x3_reduce, (1, 1), padding='same',
activation='relu')(x)
  path2 = layers.Conv2D(filters_3x3, (1, 1), padding='same',
activation='relu')(path2)

  path3 = layers.Conv2D(filters_5x5_reduce, (1, 1), padding='same',
activation='relu')(x)
  path3 = layers.Conv2D(filters_5x5, (1, 1), padding='same',
activation='relu')(path3)

  path4 = layers.MaxPool2D((3, 3), strides=(1, 1), padding='same')(x)
  path4 = layers.Conv2D(filters_pool, (1, 1), padding='same',
activation='relu')(path4)
```

```
  return tf.concat([path1, path2, path3, path4], axis=3)


inp = layers.Input(shape=(157, 320, 3))
input_tensor = layers.experimental.preprocessing.Resizing(224, 224,
interpolation="bilinear", input_shape=X_train.shape[1:])(inp)

x = layers.Conv2D(64, 7, strides=2, padding='same',
activation='relu')(input_tensor)
x = layers.MaxPooling2D(3, strides=2)(x)

x = layers.Conv2D(64, 1, strides=1, padding='same', activation='relu')(x)
x = layers.Conv2D(192, 3, strides=1, padding='same', activation='relu')(x)

x = layers.MaxPooling2D(3, strides=2)(x)

x = inception(x,
              filters_1x1=64,
              filters_3x3_reduce=96,
              filters_3x3=128,
              filters_5x5_reduce=16,
              filters_5x5=32,
              filters_pool=32)

x = inception(x,
              filters_1x1=128,
              filters_3x3_reduce=128,
              filters_3x3=192,
              filters_5x5_reduce=32,
              filters_5x5=96,
              filters_pool=64)
```

```
x = layers.MaxPooling2D(3, strides=2)(x)

x = inception(x,
              filters_1x1=192,
              filters_3x3_reduce=96,
              filters_3x3=208,
              filters_5x5_reduce=16,
              filters_5x5=48,
              filters_pool=64)

aux1 = layers.AveragePooling2D((5, 5), strides=3)(x)
aux1 = layers.Conv2D(128, 1, padding='same', activation='relu')(aux1)
aux1 = layers.Flatten()(aux1)
aux1 = layers.Dense(1024, activation='relu')(aux1)
aux1 = layers.Dropout(0.7)(aux1)
aux1 = layers.Dense(10, activation='softmax')(aux1)

x = inception(x,
              filters_1x1=160,
              filters_3x3_reduce=112,
              filters_3x3=224,
              filters_5x5_reduce=24,
              filters_5x5=64,
              filters_pool=64)

x = inception(x,
              filters_1x1=128,
              filters_3x3_reduce=128,
              filters_3x3=256,
              filters_5x5_reduce=24,
              filters_5x5=64,
              filters_pool=64)
```

```
x = inception(x,
              filters_1x1=112,
              filters_3x3_reduce=144,
              filters_3x3=288,
              filters_5x5_reduce=32,
              filters_5x5=64,
              filters_pool=64)

aux2 = layers.AveragePooling2D((5, 5), strides=3)(x)
aux2 = layers.Conv2D(128, 1, padding='same', activation='relu')(aux2)
aux2 = layers.Flatten()(aux2)
aux2 = layers.Dense(1024, activation='relu')(aux2)
aux2 = layers.Dropout(0.7)(aux2)
aux2 = layers.Dense(10, activation='softmax')(aux2)

x = inception(x,
              filters_1x1=256,
              filters_3x3_reduce=160,
              filters_3x3=320,
              filters_5x5_reduce=32,
              filters_5x5=128,
              filters_pool=128)

x = layers.MaxPooling2D(3, strides=2)(x)

x = inception(x,
              filters_1x1=256,
              filters_3x3_reduce=160,
              filters_3x3=320,
              filters_5x5_reduce=32,
              filters_5x5=128,
```

```
                filters_pool=128)

x = inception(x,
                filters_1x1=384,
                filters_3x3_reduce=192,
                filters_3x3=384,
                filters_5x5_reduce=48,
                filters_5x5=128,
                filters_pool=128)

x = layers.GlobalAveragePooling2D()(x)

x = layers.Dropout(0.4)(x)
out = layers.Dense(10, activation='softmax')(x)

model = Model(inputs = inp, outputs = [out, aux1, aux2])

model.compile(optimizer='adam', loss=[losses.sparse_categorical_crossentropy,
losses.sparse_categorical_crossentropy, losses.sparse_categorical_crossentropy],
loss_weights=[1, 0.3, 0.3], metrics=['accuracy'])


history = model.fit(X_train, [y_train, y_train, y_train], validation_data=(X_test,
[y_test, y_test, y_test]), batch_size=64, epochs=30)

fig, axs = plt.subplots(figsize=(12,8))

axs.plot(history.history['loss'])
axs.plot(history.history['val_loss'])
axs.title.set_text('Training Loss vs Validation Loss')
axs.set_xlabel('Epochs')
axs.set_ylabel('Loss')
```

```
axs.legend(['Train','Val'])

plt.show()

model.evaluate(X_test, y_test)


# EmoDB Dataset

!unzip "/content/drive/MyDrive/EmoDB.zip"

import librosa
import numpy as np

input_length = 16000*5

batch_size = 32

n_mels = 320

def preprocess_audio_mel_T(audio, sample_rate=16000, window_size=20,
#log_specgram
                 step_size=10, eps=1e-10):

        mel_spec = librosa.feature.melspectrogram(y=audio, sr=sample_rate,
n_mels= n_mels)
        mel_db = (librosa.power_to_db(mel_spec, ref=np.max) + 40)/40

        return mel_db.T


def load_audio_file(file_path, input_length=input_length):
```

```
  data = librosa.core.load(file_path, sr=16000)[0] #, sr=16000
  if len(data)>input_length:
        max_offset = len(data)-input_length

        offset = np.random.randint(max_offset)

        data = data[offset:(input_length+offset)]

  else:
        if input_length > len(data):
        max_offset = input_length - len(data)

        offset = np.random.randint(max_offset)
        else:
        offset = 0
        data = np.pad(data, (offset, input_length - len(data) - offset), "constant")

  data = preprocess_audio_mel_T(data)
  return data

# Preprocessing the dataset
import os
from scipy.io import wavfile
import librosa
import matplotlib.pyplot as plt
import numpy as np
import cv2

directory = "/content/wav/"

classes = ["W" ,"L" ,"E" ,"A" , "F" ,"T" ,"N" ]
```

```
X = list()
y = list()

for filename in os.listdir(directory):
  filePath = os.path.join(directory, filename)
  a = load_audio_file(file_path=filePath)
  data = cv2.merge([a,a,a])
  if(filename[5:6] in classes):
        X.append(data)
        y.append(classes.index(filename[5:6]))

X = np.asarray(X, dtype=np.float32)
y = np.asarray(y, dtype=np.float32)

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf

# dataset preparation

from tensorflow.keras import datasets,layers,models
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.4, train_size= 0.6
,random_state=10)

def inception(x,
              filters_1x1,
              filters_3x3_reduce,
              filters_3x3,
              filters_5x5_reduce,
              filters_5x5,
```

```
                 filters_pool):
  path1 = layers.Conv2D(filters_1x1, (1, 1), padding='same', activation='relu')(x)

  path2 = layers.Conv2D(filters_3x3_reduce, (1, 1), padding='same',
activation='relu')(x)
  path2 = layers.Conv2D(filters_3x3, (1, 1), padding='same',
activation='relu')(path2)

  path3 = layers.Conv2D(filters_5x5_reduce, (1, 1), padding='same',
activation='relu')(x)
  path3 = layers.Conv2D(filters_5x5, (1, 1), padding='same',
activation='relu')(path3)

  path4 = layers.MaxPool2D((3, 3), strides=(1, 1), padding='same')(x)
  path4 = layers.Conv2D(filters_pool, (1, 1), padding='same',
activation='relu')(path4)

  return tf.concat([path1, path2, path3, path4], axis=3)


inp = layers.Input(shape=(157, 320, 3))
input_tensor = layers.experimental.preprocessing.Resizing(224, 224,
interpolation="bilinear", input_shape=X_train.shape[1:])(inp)

x = layers.Conv2D(64, 7, strides=2, padding='same',
activation='relu')(input_tensor)
x = layers.MaxPooling2D(3, strides=2)(x)

x = layers.Conv2D(64, 1, strides=1, padding='same', activation='relu')(x)
x = layers.Conv2D(192, 3, strides=1, padding='same', activation='relu')(x)

x = layers.MaxPooling2D(3, strides=2)(x)
```

```
x = inception(x,
              filters_1x1=64,
              filters_3x3_reduce=96,
              filters_3x3=128,
              filters_5x5_reduce=16,
              filters_5x5=32,
              filters_pool=32)

x = inception(x,
              filters_1x1=128,
              filters_3x3_reduce=128,
              filters_3x3=192,
              filters_5x5_reduce=32,
              filters_5x5=96,
              filters_pool=64)

x = layers.MaxPooling2D(3, strides=2)(x)

x = inception(x,
              filters_1x1=192,
              filters_3x3_reduce=96,
              filters_3x3=208,
              filters_5x5_reduce=16,
              filters_5x5=48,
              filters_pool=64)

aux1 = layers.AveragePooling2D((5, 5), strides=3)(x)
aux1 = layers.Conv2D(128, 1, padding='same', activation='relu')(aux1)
aux1 = layers.Flatten()(aux1)
aux1 = layers.Dense(1024, activation='relu')(aux1)
aux1 = layers.Dropout(0.7)(aux1)
```

```
aux1 = layers.Dense(10, activation='softmax')(aux1)

x = inception(x,
              filters_1x1=160,
              filters_3x3_reduce=112,
              filters_3x3=224,
              filters_5x5_reduce=24,
              filters_5x5=64,
              filters_pool=64)

x = inception(x,
              filters_1x1=128,
              filters_3x3_reduce=128,
              filters_3x3=256,
              filters_5x5_reduce=24,
              filters_5x5=64,
              filters_pool=64)

x = inception(x,
              filters_1x1=112,
              filters_3x3_reduce=144,
              filters_3x3=288,
              filters_5x5_reduce=32,
              filters_5x5=64,
              filters_pool=64)

aux2 = layers.AveragePooling2D((5, 5), strides=3)(x)
aux2 = layers.Conv2D(128, 1, padding='same', activation='relu')(aux2)
aux2 = layers.Flatten()(aux2)
aux2 = layers.Dense(1024, activation='relu')(aux2)
aux2 = layers.Dropout(0.7)(aux2)
aux2 = layers.Dense(10, activation='softmax')(aux2)
```

```
x = inception(x,
              filters_1x1=256,
              filters_3x3_reduce=160,
              filters_3x3=320,
              filters_5x5_reduce=32,
              filters_5x5=128,
              filters_pool=128)

x = layers.MaxPooling2D(3, strides=2)(x)

x = inception(x,
              filters_1x1=256,
              filters_3x3_reduce=160,
              filters_3x3=320,
              filters_5x5_reduce=32,
              filters_5x5=128,
              filters_pool=128)

x = inception(x,
              filters_1x1=384,
              filters_3x3_reduce=192,
              filters_3x3=384,
              filters_5x5_reduce=48,
              filters_5x5=128,
              filters_pool=128)

x = layers.GlobalAveragePooling2D()(x)

x = layers.Dropout(0.4)(x)
out = layers.Dense(10, activation='softmax')(x)
```

```
model = Model(inputs = inp, outputs = [out, aux1, aux2])

model.compile(optimizer='adam', loss=[losses.sparse_categorical_crossentropy,
losses.sparse_categorical_crossentropy, losses.sparse_categorical_crossentropy],
loss_weights=[1, 0.3, 0.3], metrics=['accuracy'])


history = model.fit(X_train, [y_train, y_train, y_train], validation_data=(X_test,
[y_test, y_test, y_test]), batch_size=64, epochs=30)

fig, axs = plt.subplots(figsize=(12,8))

axs.plot(history.history['loss'])
axs.plot(history.history['val_loss'])
axs.title.set_text('Training Loss vs Validation Loss')
axs.set_xlabel('Epochs')
axs.set_ylabel('Loss')
axs.legend(['Train','Val'])

plt.show()

model.evaluate(X_test, y_test)
from google.colab import drive
drive.mount('/content/drive')

# Import necessary packages
import argparse

# Import necessary components to build LeNet
from keras.models import Sequential
from keras.layers.core import Dense, Dropout, Activation, Flatten
from keras.layers.convolutional import Conv2D, MaxPooling2D, ZeroPadding2D
```

```
from keras.layers import BatchNormalization
from keras.regularizers import l2

import tensorflow as tf
from tensorflow import keras
import matplotlib.pyplot as plt
%matplotlib inline
import numpy as np
import skimage.transform

def alexnet_model(img_shape=(224, 224, 3), n_classes=10, l2_reg=0.,
    weights=None):

    # Initialize model
    alexnet = Sequential()

    # Layer 1
    alexnet.add(Conv2D(30, (11, 11), input_shape=img_shape,
         padding='same', kernel_regularizer=l2(l2_reg)))
    alexnet.add(BatchNormalization())
    alexnet.add(Activation('relu'))
    alexnet.add(MaxPooling2D(pool_size=(2, 2)))

    # Layer 2
    alexnet.add(Conv2D(30, (5, 5), padding='same'))
    alexnet.add(BatchNormalization())
    alexnet.add(Activation('relu'))
    alexnet.add(MaxPooling2D(pool_size=(2, 2)))

    # Layer 3
    alexnet.add(ZeroPadding2D((1, 1)))
    alexnet.add(Conv2D(30, (3, 3), padding='same'))
```

```
alexnet.add(BatchNormalization())
alexnet.add(Activation('relu'))
alexnet.add(MaxPooling2D(pool_size=(2, 2)))

# Layer 4
alexnet.add(ZeroPadding2D((1, 1)))
alexnet.add(Conv2D(30, (3, 3), padding='same'))
alexnet.add(BatchNormalization())
alexnet.add(Activation('relu'))

# Layer 5
alexnet.add(ZeroPadding2D((1, 1)))
alexnet.add(Conv2D(30, (3, 3), padding='same'))
alexnet.add(BatchNormalization())
alexnet.add(Activation('relu'))
alexnet.add(MaxPooling2D(pool_size=(2, 2)))

# Layer 6
alexnet.add(Flatten())
alexnet.add(Dense(30))
alexnet.add(BatchNormalization())
alexnet.add(Activation('relu'))
alexnet.add(Dropout(0.5))

# Layer 7
alexnet.add(Dense(30))
alexnet.add(BatchNormalization())
alexnet.add(Activation('relu'))
alexnet.add(Dropout(0.5))

# Layer 8
alexnet.add(Dense(n_classes))
```

```
    alexnet.add(BatchNormalization())
    alexnet.add(Activation('softmax'))

    if weights is not None:
        alexnet.load_weights(weights)

    return alexnet

def parse_args():
    """
    Parse command line arguments.
    Parameters:
        None
    Returns:
        parser arguments
    """
    parser = argparse.ArgumentParser(description='AlexNet model')
    optional = parser._action_groups.pop()
    required = parser.add_argument_group('required arguments')
    optional.add_argument('--print_model',
        dest='print_model',
        help='Print AlexNet model',
        action='store_true')
    parser._action_groups.append(optional)
    return parser.parse_args()

def load_preprocess_training_batch(X_train):

       new = []

       for item in X_train:
       tmpFeature = skimage.transform.resize(item, (224, 224), mode='constant')
```

```
        new.append(tmpFeature)

        return new

# CIFAR 10 DATASET

# Command line parameters
# args = parse_args()

# Create AlexNet model
model = alexnet_model()

# Print
# if args.print_model:
#     model.summary()

(X_train, y_train) , (X_test, y_test) = keras.datasets.cifar10.load_data()

X_train = X_train[0:500]
y_train = y_train[0:500]
X_test = X_test[0:200]
y_test = y_test[0:200]

X_train_resized = load_preprocess_training_batch(X_train)
X_test_resized = load_preprocess_training_batch(X_test)

X_train_resized = np.array(X_train_resized)
X_test_resized = np.array(X_test_resized)

X_train_resized = X_train_resized / 255
X_test_resized = X_test_resized / 255
```

```
model.compile(optimizer='SGD',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(X_train_resized, y_train, epochs=5)

model.evaluate(X_test_resized, y_test)

# NMIST Dataset

(X_train, y_train) , (X_test, y_test) = keras.datasets.mnist.load_data()

X_train = X_train[0:2000]
y_train = y_train[0:2000]
X_test = X_test[0:2000]
y_test = y_test[0:2000]

X_train_resized = load_preprocess_training_batch(X_train)
X_test_resized = load_preprocess_training_batch(X_test)

X_train_resized = np.array(X_train_resized)
X_test_resized = np.array(X_test_resized)

X_train_resized = X_train_resized / 255.0
X_test_resized = X_test_resized / 255.0

import cv2

X_train_new = list()

for i in range(len(X_train_resized)):
  g  = X_train_resized[i]
```

```
  X_train_new.append(cv2.merge([g,g,g]))

X_train_new = np.asarray(X_train_new,dtype=np.float32)

X_test_new = list()

for i in range(len(X_test_resized)):
  g  = X_test_resized[i]
  X_test_new.append(cv2.merge([g,g,g]))

X_test_new = np.asarray(X_test_new,dtype=np.float32)

model = alexnet_model()

model.compile(optimizer='SGD',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(X_train_new, y_train, epochs=5)

model.evaluate(X_test_new, y_test)

# SAVEE Dataset

!unzip "/content/drive/MyDrive/SaveeDataset.zip"

import librosa
import numpy as np

input_length = 16000*5

batch_size = 32
```

```
n_mels = 320

def preprocess_audio_mel_T(audio, sample_rate=16000, window_size=20,
#log_specgram
                 step_size=10, eps=1e-10):

        mel_spec = librosa.feature.melspectrogram(y=audio, sr=sample_rate,
n_mels= n_mels)
        mel_db = (librosa.power_to_db(mel_spec, ref=np.max) + 40)/40

        return mel_db.T



def load_audio_file(file_path, input_length=input_length):
  data = librosa.core.load(file_path, sr=16000)[0] #, sr=16000
  if len(data)>input_length:
        max_offset = len(data)-input_length

        offset = np.random.randint(max_offset)

        data = data[offset:(input_length+offset)]

  else:
        if input_length > len(data):
        max_offset = input_length - len(data)

        offset = np.random.randint(max_offset)
        else:
        offset = 0
        data = np.pad(data, (offset, input_length - len(data) - offset), "constant")
```

```
  data = preprocess_audio_mel_T(data)
  return data

# Preprocessing the dataset
import os
from scipy.io import wavfile
import librosa
import matplotlib.pyplot as plt
import numpy as np
import cv2

rootDirectory = "/content/AudioData/"
personNames = ["DC","JE","JK","KL"]

classes = ["a" , "d" , "f", "h", "n", "sa" , "su" ]

X = list()
y = list()

for person in personNames:
  directory = os.path.join(rootDirectory,person)
  for filename in os.listdir(directory):
        filePath = os.path.join(directory, filename)
        a = load_audio_file(file_path=filePath)
        data = cv2.merge([a,a,a])
        if(filename[0:1] in classes):
        X.append(data)
        y.append(classes.index(filename[0:1]))
        elif(filename[0:2] in classes):
        X.append(data)
        y.append(classes.index(filename[0:2]))
```

```
X = np.asarray(X, dtype=np.float32)
y = np.asarray(y, dtype=np.float32)

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf

# dataset preparation

from tensorflow.keras import datasets,layers,models
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.5, train_size= 0.5
,random_state=10)

X_train_resized = load_preprocess_training_batch(X_train)
X_test_resized = load_preprocess_training_batch(X_test)

X_train_resized = np.array(X_train_resized)
X_test_resized = np.array(X_test_resized)

model = alexnet_model()

model.compile(optimizer='SGD',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(X_train_resized, y_train, epochs=10)

model.evaluate(X_test_resized, y_test)

# EmoDB Database
```

```
!unzip "/content/drive/MyDrive/EmoDB.zip"

import librosa
import numpy as np

input_length = 16000*5

batch_size = 32

n_mels = 320

def preprocess_audio_mel_T(audio, sample_rate=16000, window_size=20,
#log_specgram
                 step_size=10, eps=1e-10):

        mel_spec = librosa.feature.melspectrogram(y=audio, sr=sample_rate,
n_mels= n_mels)
        mel_db = (librosa.power_to_db(mel_spec, ref=np.max) + 40)/40

        return mel_db.T


def load_audio_file(file_path, input_length=input_length):
  data = librosa.core.load(file_path, sr=16000)[0] #, sr=16000
  if len(data)>input_length:
        max_offset = len(data)-input_length

        offset = np.random.randint(max_offset)

        data = data[offset:(input_length+offset)]
```

```
  else:
        if input_length > len(data):
        max_offset = input_length - len(data)

        offset = np.random.randint(max_offset)
        else:
        offset = 0
        data = np.pad(data, (offset, input_length - len(data) - offset), "constant")

  data = preprocess_audio_mel_T(data)
  return data

# Preprocessing the dataset
import os
from scipy.io import wavfile
import librosa
import matplotlib.pyplot as plt
import numpy as np
import cv2

directory = "/content/wav/"

classes = ["W" ,"L" ,"E" ,"A" , "F" ,"T" ,"N" ]

X = list()
y = list()

for filename in os.listdir(directory):
  filePath = os.path.join(directory, filename)
  a = load_audio_file(file_path=filePath)
  data = cv2.merge([a,a,a])
  if(filename[5:6] in classes):
```

```
        X.append(data)
        y.append(classes.index(filename[5:6]))

X = np.asarray(X, dtype=np.float32)
y = np.asarray(y, dtype=np.float32)

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf

# dataset preparation

from tensorflow.keras import datasets,layers,models
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.4, train_size= 0.6
,random_state=10)

X_train_resized = load_preprocess_training_batch(X_train)
X_test_resized = load_preprocess_training_batch(X_test)

X_train_resized = np.array(X_train_resized)
X_test_resized = np.array(X_test_resized)

model = alexnet_model()

model.compile(optimizer='SGD',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(X_train_resized, y_train, epochs=10)
```

```
model.evaluate(X_test_resized, y_test)
```